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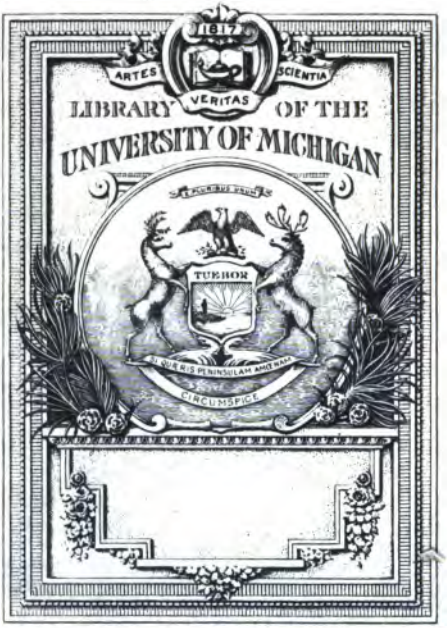
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A MATHEMATICAL
MANUAL:
OR,
Delightful Aſſociate.

CONTAINING,

I. A Deſcription and Uſe of the CELESTIAL GLOBE: How to know the Stars in each Conſtellation, and their Magnitude; alſo their Latitude, Longitude, Right Aſcenſion, Declination, Semi-diurnal Ark, Riſing, Southing, Setting, Altitude, Azimuth, Diſtances, *&c.* The Sun's Place, his Riſing and Setting, Length of the Day and Night, *&c.* Alſo Dialling by this Globe.
II. Twelve Problems relating chiefly to the MOON: And a truer Way than has been given to find EASTER, *&c.* The Hour of the Night by the Moon ſhining on a Sun-Dial, *&c.*
III. A Deſcription and Uſe of the TERRESTRIAL GLOBE, as to Climates, Zones, *Shadows*, Inhabitants, Latitude and Longitude of Places: And a large TABLE, ſhewing where all the moſt remarkable Places in the World may be placed on Dials; and the Bearing and Diſtance of ſuch Places from *London.*
IV. A full Deſcription and Uſe of all Kinds of MAPS: With a copious TABLE of the Latitude, Longitude, and Situation of the chief Cities on Earth: And many other curious Matters.
V. The Original of the Lines in a SECTOR deſcrib'd; with the full Uſe of that Inſtrument in Trigonometry, *&c.* in an Eaſy Natural Method.
VI. How to make a Line of NUMBERS, or LOGARITHMS, to any Length, and the full Uſe in all Parts of Arithmetic.
VII. MYSTERIOUS CURIOSITIES in Numbers: Or, *Numerical* NOVELTIES. In Twenty-five PROPOSITIONS, moſtly New, and very Eaſy and Delightful.
VIII. How to take Heights, Depths, and Diſtances, great or ſmall, by ſeveral Ways and Inſtruments. In Twelve PROPOSITIONS.

The Whole very USEFUL and PLEASANT.

Publiſhed for the Contemplation and Diverſion of GENTLEMEN, and Others, who are *Mathematically* inclined.

By *E.*dward *HATTON*, Gent.

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Hist. of Science
Dawson
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TO
Thomas Frewen, Eſq;
Of *Brickwall* in the County
of SUSSEX;
AS A
Judicious Favourer of LEARNING,
AND
Encourager of Uſeful and
Commendable SCIENCES;
THIS
TREATISE,
With Sincere RESPECT,
And Profound DEFERENCE,
Is DEDICATED;

By his Moſt Obedient
Humble Servant,

E. HATTON.

TO THE
READER.

THIS *is now the Twelfth Treatiſe (moſtly on the Subject of Numbers) wherewith I have endeavoured to be of ſome Service, and to oblige Mankind; to whom I muſt acknowledge my Gratitude juſtly due for the kind Acceptance I have met with; near Forty-thouſand having been ſold off, beſides ſome Thouſands alſo of the four Books by me peruſed and corrected. And as this will be the laſt that I intend to write, ſo I am not without Hopes it will meet with the like Reception, ſo many of the Contents being Copious and New, as well as Pleaſant and Delightful, handled in an Eaſy* *and Familiar Way, Intelligible by a mean Capacity.*

But tho' the Publick in general hath favoured me, yet I have not had the Good-Fortune to find ſuch Encouragement from thoſe who ſhould (I think, without a fond Partiality to Self) have ſhewed ſome Regard to my Labours, which have chiefly been calculated and adapted to the promoting the Science of Trade and Commerce. But, alas! there are too many who are ſo indolent and little concern'd about thoſe Matters (which, next to Religion itſelf, do claim our greateſt Reſpect) Humour and Pleaſure having ſo much the Aſcendant, that the Author of a Play or whimſical Novel ſhall ſooner meet with the Reward of conſiderable Buſineſs, or an Employment of Profit, than he who hath ſpent more than half an Age of Sixty-three Years in Studies which tend very greatly to the Knowledge and Increaſe of Trade and Merchandizing,

chandizing, the principal Inſtruments of the Nation's Grandeur and Riches. However, as it is our Duty, ſo is it our Wiſdom and Intereſt, to be ſubmiſſive to the Allotment of Providence, that if we fall ſhort of receiving from Men what we with good Reaſon preſume we deſerve; *we may be ſo far reſigned, as not impiouſly to deſire more than we* have.

But ſince I am upon this Topic, I hope to be excuſed, if I relate one Inſtance of Service more immediately to the Government; which was this: In the Year 1697, *I compos'd Tables for the Uſe of the Collectors and Receivers of the Capitation Tax; which contained not only all Duties payable by the ſeveral Claſſes or Degrees of People, but alſo the preciſe Weight, in the old Clipt Money, that would anſwer thoſe Payments, all in ſo plain a Method, that the Collectors, both in the City and Country, declared they did not know what to do without them; and mine* *were the only Tables for that neceſſary Uſe that were made publick.*

As to this Book, I have only farther to ſay in general, That it contains many Things more than the Title intimateth; and I doubt not but will every Way anſwer the Expectation of a judicious and impartial Reader: and for the critical Carper Zoilus, *'tis not neceſſary to beſpeak his Candour.*

Our Globes and Maps, and moſt other Inſtruments, only having Degrees, we are forced in moſt Caſes to gueſs at the Minutes: And therefore, as the preciſe Truth in them is not very neceſſary; ſo it cannot be expected that the Minutes ſhould be better exhibited, ſetting aſide Trigonometrical Calculations, which would differ from the Uſe of Inſtruments, in the very Subject, and of the Art's Denomination; one being the Uſe of Globes, Maps, &c. *and the other plain or ſpherical Trigonometry.*

A MATHEMATICAL

MANUAL.

SECT. I.

The Deſcription *and* Uſe *of the* CELESTIAL GLOBE.

I. THE *Globe* is every way round; the Ambits, or Circumferences, being equal, which way ſoever you take them, in the Middle of the Globe.

II. *The Parts of the Globe* are, 1. *The Ball or Body of the Globe* whereon the Circles of the Sphere are drawn, and the Stars are painted in ſeveral Conſtellations. 2. *The Axis*, which is ſuppoſed to extend through the Middle of the Globe, the Ends of which are the North and South Poles of the World. 3. *The brazen Meridian*, which encompaſſeth the Ball, and wherein the Poles are fixed, and which doth reſt on a Pedeſtal under the Ball; which Meridian is to be moved ſo as to bring the Poles nearer to, or farther from, the Horizon. 4. *The Horizon* is, as it were, the Frame, wherein the Globe is fixed, and which the Meridian croſſes at right Angles; of which more below. 5. *The Quadrant of Altitude*, which is 90 Degrees, marked out upon a thin Piece of Braſs, that will comply ſo as to meaſure any Diſtance on this or the Terreſtrial Globe, for both which one Quadrant of Altitude is ſufficient, and 'tis made to ſcrew on the Meridian, and upon a Rivet to turn round any way. 6. *The Hour-Circle*, which is divided into twice twelve Hours, for Morning and Afternoon: It is fixed ſo to the Meridian, that the Pole is its Center; whereon is put, 7. *The Index*, ſo contrived as to turn round with the Ball, and yet is not ſo faſt but that it may be turned and ſet to any Hour. It is put upon the Pole, or End of the Axis of the Globe.

III. *The Circles deſcribed on the Celeſtial Globe* are theſe; ſix Great, and four Small. A Great [illegible] Circle is [illegible]

Circle is one that divideth the Globe into two equal Parts: As,

1. *The Equinoctial*, which extends round the Globe in the middle Way between the two Poles of the World, and 'tis divided into 360 equal Parts, beginning at the Place where it is interſected by the Ecliptic, and by one of the Colures. From this Circle the Declination of the Sun and Stars is reckoned in the Meridian Northward and Southward; and alſo their right Aſcenſion is computed upon this Circle from the firſt Point of *Aries*. And when the Sun comes to this Circle (which it does twice in the Year, about the 10th of *March*, and 12th of *September*) it makes equal Days and Nights: Whence its Name.

2. *The Meridian* here moſt obſervable, is that of Braſs, wherein the Poles are fixed: For there are ſuppos'd innumerable Meridians; but the Brazen one is of chief Uſe, becauſe any Star or Sun's Place can be brought to it, and the Altitudes, Right Aſcenſion, Declination, *&c.* are thereby diſcover'd. It is divided into 4 Nineties, or 4 times 90 Degrees; and a Degree muſt therefore be the 360th Part of any Circle. When the Sun comes to the Meridian of any Place, it is there 12 of the Clock at Noon; and again 12, or Midnight, 12 Hours afterwards. And there are Meridians drawn

through every 30 Degrees of the Equinoctial (or 12 in all;) ſo that 15 Degrees being equal to 1 Hour, 30 are 2 Hours; and conſequently the 12 Meridians, each 2 Hours of the Equinoctial, make 24 Hours. And in that Proportion of 15 Degrees of Motion being 1 Hour of Time, 1 Degree is 4 Minutes of Time.

3. *The Ecliptic Line* is the third Great Circle. It is divided into 12 equal Parts, anſwering to the 12 Signs of the *Zodiac*, and each Sign into 30° (or Degrees) marked thus:

Aries, mark'd	♈	*Libra*,	♎
Taurus,	♉	*Scorpio*,	♏
Gemini,	♊	*Sagittarius*,	♐
Cancer,	♋	*Capricorn*,	♑
Leo,	♌	*Aquarius*,	♒
Virgo,	♍	*Piſces*,	♓

The Circles that divide the Ecliptic into 12 equal Parts at right Angles, are Great Circles, called Circles of Longitude; becauſe from them to the firſt Point of *Aries* is reckoned the Longitude of the Stars: as the Latitude is upon thoſe Circles (or others made by the Quadrant of Altitude) from the Ecliptic to the Star and Pole of the Ecliptic, as appears hereafter.

4. *The Horizon*, which is that Circle which divides the viſible from the inviſible Parts of

the Heavens. It is the Frame of the Globe, whereon are ſhewn the 12 Signs, painted between the Degrees in each Sign. Secondly, You have the Days in every Month anſwering to thoſe Signs, and the Letters for every Day, by Way of Calendar, according to the *Julian* (or common) Account; and farther outward are the like, according to the *Roman*, or New, or *Gregorian* Account; and farther outward are the 32 Points of the Compaſs, each Point being $11\frac{1}{4}$ Degrees. This Circle, or Horizon, is uſed in finding the Sun's Riſing, Amplitude, Azimuth, *&c.* as in the following Problems appears.

5. *The Equinoctial Colure*, which is a great Circle paſſing through the Poles of the World, and cutting the Equinoctial at right Angles in the firſt Point of the two Equinoctial Signs *Aries* and *Libra*; whence, and toward each Pole, this Circle is divided into four ninety Degrees.

6. *The Solſtitial Colure* is another great Circle, paſſing through the Poles of the World, and croſſes both the Equinoctial and Ecliptic at right Angles, in the firſt Points of *Cancer* and *Capricorn*; to which when the Sun comes, begins Summer and Winter; as it does by the other Colure diſtinguiſh Spring and Autumn.

7. *The leſſer Circles* are, firſt, *The Tropic of Cancer*, the Boundary of the Sun's Courſe, and 23°. 30′. from the Equinoctial Northward. As,

8. *The Tropic of Capricorn* is the Boundary of the Sun's Courſe, and is 23°. 30′. from the Equinoctial Southward.

9. *The Artic*; and,

10. *The Antartic Circles*. The firſt 23°. 30′. from the North Pole, and the ſecond as much from the South Pole: Of which more in the *Deſcription and Uſe of the Terreſtrial Globe*.

IV. *The Points* to be obſerved are, 1. The North Pole; 2. The South Pole; each 90° from the Equinoctial. 3. The Poles of the Ecliptic, which are each 90 Degrees from it, and 23°. 30′. from the Poles of the World. 4. The Zenith is the Point directly over your Head whereſoever you be. 5. The Nadir, or Point under your Feet. Theſe are the Poles of the Horizon, being 90 Degrees from it.

The Poſitions of the Globe are 3, viz.

1. Direct, when the Poles are in the Horizon; as it is to thoſe who live under the Equinoctial.

2. Parallel Sphere is when the Poles are in the Zenith and Nadir, and the Equinoctial is coincident with the Horizon; as it is to thoſe that live under the Poles.

3. The Oblique Sphere is when the Poles are elevated or depreſſed ſome Number of Degrees between the Horizon and the Zenith or Nadir, and the Equinoctial and Parallels of Declination do cut the Horizon at Oblique Angles.

The Stars put on the Globe are to be known alſo, by the Eye, in the Heavens, by their Magnitudes and Declination, or Diſtance North or South from the Equinoctial, or from the Pole. The Magnitudes are diſtinguiſhed on the Globe thus: Stars of

Magn.		*Rays.*	*Magn.*		*Rays.*
1	have	16	4	have	6
2		10	5		5
3		8	6		3

They are alſo painted in ſeveral Conſtellations (or Figures of Men, Women, Birds, Beaſts, Fiſh, &c.) The Northern Conſtellations,

tions, or thoſe ſo near the North Pole as to be viſible in our Horizon, are,

Urſa Minor, with the Pole Star at the End of his Tail, of the ſecond Magnitude.

Urſa Major, having 4 in his Body, and 3 in his Tail, of the ſecond Magnitude.

Cor Caroli, under the Tail of the *Great Bear*, 1 of the ſecond Magnitude.

And there are more having Stars of Note, viz.

Cephus (a King of *Ethiopia*, Father of *Andromeda*;) 3 of 3d, and 4 of the 6th Magn.

Draco, (the *Dragon*) next the *Little Bear*, 7 of the 3d.

Bootes is the next; 6 of 3d, and 1 of the 1ſt.

Corona Septent. (or *North Crown*;) 1 of 2d, and 5 of 4th.

Lyra, the *Harp*; 1 of 1ſt, and 2 of 3d.

Hercules; 8 of 3d.

Coma Berenices, (the *Hair* of *Ptolomy's Daughter*;) 1 of 3d, and 10 leſſer.

Cygnus, (the *Swan*) South from *Draco*; 1 of ſt, 1 of 2d, and 6 of 3d.

Caſſiopea (*Cephus's* Daughter) and her *Chair*; f 3d, and 4 of 4th.

Perſeus, (Son of *Jupiter*, that cut off *Meduſa's* Head ;) 1 of 2d, and 6 of 3d.

Andromeda, with her *Chain* ; 3 of 2d, and 3 of 3d.

Auriga, and his *Goat*, *Hircus* ; 1 of 1ſt, and 2 of 2d.

Pegaſus, (or the Flying-Horſe of *Perſeus* ;) 3 of 2d, and 4 of 3d.

Aquila, (the Eagle volant) South from *Lyra* ; 1 of 2d, and 5 of the 3d.

The *Dolphin*, between *Pegaſus* and the *Eagle* ; 3 of 3d.

The *Triangle*, Southward from *Andromeda's* Foot ; 3 of 4th.

The following are in the twelve Signs.

Aries, (the *Ram*) between his Horns ; 1 of 3d.

Taurus, (the *Bull*) his Eye, or rather his Forehead, *Aldebaran* ; 1 of 1ſt. Alſo in the *Bull* are the *Pleïades*, or 7 Stars ; 1 of 4th, and one of 5th.

Gemini, (the *Twins*) *Caſtor* and *Pollux* ; 3 of 2d, and 4 of 3d.

Cancer, (the *Crabfiſh* ;) 1 of 3d, and 2 of 4th.

Leo, (the *Lion*,) his Heart and Tail; 2 of the 1ſt; alſo 2 of the 2d.

Virgo's *Spike*; 1 of 1ſt, 3 of 3d.

Libra, (the *Ballance*,) the South-Weſterly 1 of the 1ſt; North-Eaſterly 1 of the 2d; and the Center of Gravity in the Beam, (*Zubenenelſchemali*,) 1 of the 2d.

Scorpio's *Heart*, 1 of 1ſt. Near his Tail, 1 of the 2d, and 2 of the 3d.

Sagittarius, (the *Bowman*,) one in his Left-Hand, and 2 in that Arm, of 3d.

Capricornus, (the *Sea-Goat*,) 2 by his Horns, and 2 in his Tail, of 3d.

Aquarius, 1 in his Left Shoulder, 1 on his Right Thumb, and 1 on his Right Knee, of the 3d.

Piſces, 7 of the 5th Magnitude.

Fomahant, under *Aquarius*'s Waterpot, and about 8°, when on the Meridian, above the South Horizon; 1 of the 1ſt.

Cetus, the *Whale*; 1 in his Mouth, of the 2d; 4 in his Head, and 5 in his Body, of the 3d; and 1 near his Belly and Tail, of the 2d.

Orion; on his Left Thigh, 1 of the 1ſt; 1 on his Right, and 1 on his Left Shoulder, and 3 in the Belt, of the 2d; 2 in his Skirt, and 1 on his Left Side, of the 3d.

Lepus, (the *Hare*;) 4 on his Left Side, of the 3d; and 5 more of the 4th and 5th.

Canis Major (the *Greater Dog*, *Syrius*;) 1 on his under Jaw, of the 1ſt; 1 on his Right Foot, of the 2d; and 5 more, of the 3d.

Canicula (the *Little Dog*, or *Procyon*;) 1 on his Left Thigh, of the 2d; and 1 in his Neck, of the 3d.

Hydra's Heart, (*Alphard*;) 1 of the 1ſt; and in his Body, 5 of 3d.

Corvus (the *Greedy Cormorant*) near *Hydra*'s Tail; 2 of the 3d.

Antinous (or the Youth of *Bithynia* in *Natolia*, or *Leſſer Aſia*;) 5 of the 3d, under *Aquila*.

Theſe make 40 Conſtellations, having about 850 Stars.

And in the Southern Part, or below the Horizon, there are the *Peacock*, the *Centaur*, *Camelion*, &c. about 18 Conſtellations (inviſible to us) having about 500 Stars.

So much for the DESCRIPTION.

The Uſe *of the* CELESTIAL GLOBE.

To Rectify the GLOBE.

FIX the Pole of the World, which is in the Braſs Meridian, ſo many Degrees above the Horizon, as is the Latitude of the Place, and ſcrew the Quadrant of Altitude in the Zenith, or the Complement of the Latitude, which for the Lat. of *London*, 51.32, is 38°. 28'.

PROBLEM I.

The Day of the Month given to find the Sun's Place in the Ecliptic.

THIS is done by the Table delineated on the Frame of the Globe, or Horizon; Finding there the Day of the Month, you have right againſt it the Sun's Place. Thus,

January 1. the Sun's Place is	21	46	♑
April 1.	22	20	♈
May 28.	17	00	♊
Nov. 4.	22	46	♏

PRO-

PROB. II.

The Sun's Place in the Ecliptic given to find the Day of the Month.

LOOK in the Diviſions next the Ball, or ſecond from it, for the Sun's Place, and in the third divided Circle from the Ball you have the Day of the Month according to our *Julian* Account: So

The Sun being in	*The Day of the Month is*
° ′	
21 46 ♑	Jan. 1.
17 00 ♊	May 28, *&c.*

PROB. III.

To find the Sun's Right Aſcenſion by having the Day of the Month given.

THE Right Aſcenſion of the Sun is an Arch of the Equinoctial, which comes to the Meridian with the Degree and Minute of the Sun's Place in the Ecliptic, reckon'd from the 1ſt Point of *Aries.*

So that having rectify'd the Globe as above, find the Sun's Place in the Ecliptic; as by *Prob.* I.

Then bring the Sun's Place to the Meridian, and the Degrees then cut by the Meridian in the Equinoctial from the firſt Point of *Aries*, is the Anſwer.

EXAMPLE.

What is the Right Aſcenſion of the Sun, May 28?

THE Sun's Place found, as before, is 17 Degrees of *Gemini*, which bring to the Meridian, and there will then be from the firſt Point of *Aries* to the Meridian in the Equinoctial 76 Degrees, equal to the Anſwer. In like manner,

	Sun's Place.			*Right Aſcenſion.*	
	°	′		°	′
Jan. 1.	21	46 of	♑	293	10
Apr. 1.	22	20	♈	20	40
Nov. 4.	22	46	♏	230	30
Dec. 25.	14	50	♑	286	00

PROB. IV.

To find the Sun's Declination.

THE Day of the Month given, find the Sun's Place for that Day, as before, then bring it to the Meridian, and the Degrees there between the Sun's Place and the Equinoctial is the Declination required. Thus,

	Sun's Place.		Declination.	
Jan. 1.	21	46 ♑	21	36 South.
Apr. 1.	22	20 ♈	8	20 N.
Nov. 4.	22	46 ♏	18	35 S.
Dec. 25.	14	50 ♑	22	30 S.

PROB. V.

To find the Sun's Amplitude any Day.

THE Amplitude is an Arch of the Horizon, contained between the Sun's Place in the Ecliptic and the Eaſt or Weſt Points of the Horizon: So bring the Sun's Place to the Horizon, and you ſee the Anſwer. So

	Sun's Place.			*From the Eaſt.*	
	°	'		°	'
Jan. 1.	21	46 ♑	*Ampl.*=	37	00 S.
Apr. 1.	22	20 ♈		13	30 N.
Nov. 4.	22	46 ♏		31	00 S.
Dec. 25.	14	50 ♑		39	50 S.

PROB. VI.

To find the Oblique Aſcenſion of the Sun.

WHICH is an Arch of the Equinoctial, included between the Eaſt Point of the Horizon and the firſt Point of *Aries*, after the Sun's

Place in the Ecliptic for that Day is brought to the Horizon: As by theſe Examples.

	Sun's Place.			*Oblique Aſcenſion.*	
	°	′		°	′
Jan. 1.	21	46	♑	324	00
Apr. 1.	22	20	♈	10	40
Nov. 4.	22	46	♏	255	30
Dec. 25.	14	50	♑	318	40

PROB. VII.

To find the Sun's Meridian Altitude any Day.

THIS is an Arch of the Meridian between the Sun's Place and the Horizon. As for Example,

	Sun's Place.			*Merid. Altitude.*	
	°	′		°	′
Jan. 1.	21	46	♑	16	30
Apr. 1.	22	20	♈	46	30
Nov. 4.	22	46	♏	19	30
Dec. 25.	14	50	♑	16	00

PROB. VIII.

To find the Time of the Sun's Riſing or Setting any Day.

PUT the Sun's Place in the Ecliptic to the Meridian, then ſet the Index of the Hour-Circle to the upper 12; then turn the Sun's Place to the Eaſt Part of the Horizon; and then the Index will cut the Time of the Sun's Riſing in the ſaid Hour-Circle.

EXAMPLE.

	Sun's Place.			*Sun riſeth.*	
	°	′		h.	′
Jan. 1.	21	46	♑	08	00
Apr. 1.	22	20	♈	05	21
Nov. 4.	22	46	♏	07	40
Dec. 25.	14	50	♑	08	02

Note, That having the Time of the Sun's Riſing, you have alſo the Time of the Sun's Setting, by deducting from 12: And the Length of the Day is double the Time at which the Sun ſets; and the Length of the Night is double the Time of Sun-riſing. Thus,

	Sun riſes.	*Sun ſets.*	*Length of Day.*	*Length of Night.*
	h. ′	*h.* ′	*h.* ′	*h.* ′
Jan. 1.	8—00	4—00	08—00	16—00
Apr. 1.	5—21	6—39	13—18	10—42
Nov. 4.	7—40	4—20	08—40	15—20
Dec. 25.	8—02	3—58	07—56	16—04

PROB. IX.

To find the Time of Day-Break, and End of Twy-light. This is when the Sun is eighteen Degrees below the Horizon, before its Riſing, and after its Setting.

RECTIFY the Globe as to Latitude, and the Quadrant of Altitude ſcrew'd in the Zenith; then (*for Day-Break*) firſt find the Sun's Place in the Ecliptic, and bring that to the Meridian, and the Hour Index to 12; then bring the Degree of the oppoſite Sine to the Meridian, and move the Ball and Quadrant of Altitude on the Weſt Side of the Meridian, till the Degree of the oppoſite Sine fall juſt under 18 Degrees of the Quadrant of Altitude; then the Index will cut the Time of Day-break in the Hour-Circle.

And for the End of Twylight (or the Light of the Sun after its Setting) deduct the Time of Day-break from 12 Hours. Thus,

	Sun's Place.	*Day breaks.*	*Twyl. ends.*
	° '	*h.* '	*h.* '
Jan. 1.	21—46 ♑	5—40	6—20
Apr. 1.	22—20 ♈	3—09	8—51
Nov. 4.	22—46 ♏	5—38	6—22
Dec. 25.	14—50 ♑	5—48	6—12

Note, The oppoſite Signs are thus:

Aries,	*Libra*,
Taurus,	*Scorpio*,
Gemini,	*Sagittarius*,
Cancer,	*Capricorn*,
Leo,	*Aquarius*,
Virgo,	*Piſces.*

PROB. X.

To find the Sun's Altitude at any Time of the Day, the Sun's Place and Time of Day given.

HAVING brought the Sun's Place in the Ecliptic to the Meridian, and put the Hour to 12 a-Clock; turn the Globe till the Hour's Index points to the Hour of the Day given; then lay the Quadrant of Altitude on the Sun's Place, and it will cut the Altitude.

EXAMPLE.

What is the Altitude of the Sun on the Days and Hours following?

	Sun's Place.	*Time of Day.*	*Alt. ſought.*
	° ′	*h.* ′	° ′
Jan. 1.	21—40 ♑	02—30 p. m.	09—30
Apr. 1.	22—20 ♈	04—30 p. m.	21—00
Nov. 4.	22—45 ♏	09—30 a. m.	12—30
Dec. 25.	14—50 ♑	10—30 a. m.	13—00

PROB. XI.

To find the Sun's Azimuth (or what Point of the Compaſs it ſhines from) at any Altitude.

TURN the Globe to the Weſtward if Afternoon, or to the Eaſtward if Morning, till the Sun's Place lies juſt under the Sun's Altitude on the Quadrant of Altitude, which will then cut the Azimuth in the Horizon.

Sun's Place.	*Altitude.*	*Azimuth from South.*
° ′	° ′	° ′
21—46 ♑	09—30 p.m.	34—30 S.W.*by*S.*near*
22—20 ♈	21—00 p.m.	76—00 W. *by* S.
22—46 ♏	12—30 a.m.	36—30 S.E. *by*S. *near*
14—50 ♑	13—00 a.m.	21—20 S. S. E.

PROB. XII.

To find the Hour of the Day, having the Sun's Place and Altitude given.

BRING the Sun's Place to the Meridian, and put the Index of the Hour-Circle to 12; then turn the Globe (Eaſtward if before Noon, or Weſtward if after) till the Altitude on the

Quadrant meet, and fall on the Sun's Place; when the Index will point to the Hour in the Circle upon the Pole. Thus,

Sun's Place.	*Altitude.*	*Hour of the Day.*
° '	° '	
21—46 ♑	09—30 p. m.	02—30
22—20 ♈	21—00 p. m.	04—30
14—50 ♑	13—00 a. m.	10—30

PROB. XIII.

To find the Length of the longeſt Day in any Latitude.

RECTIFY the Globe to the Latitude, ſuppoſe 51.32'; Secondly, Bring the Solſtitial Colure to the Meridian; Thirdly, Put the Hour-Index to 12; Fourthly, Bring the Interſection of the Colure, with the Tropic of *Cancer*, to the Horizon; and then the Index will cut $8^{h.}$ $15'$; which doubled is $16^{h.}$ $30' =$ the longeſt Day. And the like by the Tropic of *Capricorn* gives $3\frac{3}{4}^{h.}$; which doubled, gives $7\frac{1}{2}^{h.}$, the ſhorteſt Day.

So alſo in the Latitude of 40°, of 30°, or 20°, the *longeſt* and *ſhorteſt* Days are as follow:

	The longeſt Day is	*The ſhorteſt Day is*
°	*h.* ′	*h.* ′
40	15—00	09—30
30	14—16	10—30
20	13—30	11—00

PROB. XIV.

To find the Difference in Time contained in the ſame Number of Days in different Parts of the Year.

FIND the Sun's Place, and then the right Aſcenſion, and take their firſt and ſecond Differences; and the laſt converted into Time, gives the Anſwer.

Note, 15 Degrees is 1 Hour, and 1 Degree = 4 Min.

EXAMPLE.

	Sun's Place.	*Right Asc.*	*Difference.*	*Diff. of Diff.*
	° ′	° ′	° ′	° ′
June 1.	21—03 ♊	080—45	30—15	1—5, *or* 4$\frac{1}{3}$ *in* (*time.*
July 1.	19—35 ♋	111—00		
Jan. 1.	21—46 ♑	293—00	31—20	
31.	22—35 ♒	324—20		

EXAMPLE II.

	Sun's Place.	*Right Asc.*	*Difference.*	*Diff. of Diff.*
	° ′	° ′	° ′	° ′ ″
Mar. 1.	21—40 ♓	352—00	18—30	3—40, *or* 15 (*time propè.*
21.	11—30 ♈	10—30		
Dec. 1.	20—12 ♐	259—20	22—10	
21.	10—50 ♑	281—30		

Now the Reaſon of the Difference is this: Suppoſe another Sun at no Degrees of the Equinoctial to commence its diurnal Rotation from the ſame Meridian at the ſame Moment that our Sun doth; that Sun, or Mark in the Equinoctial, will paſs round to the ſame Point again in twenty-four Hours: But the Sun itſelf will return ſometimes later to that ſame Meridian, and conſequently will make a longer Day than the true Day of twenty-four Hours, made by the Equinoctial, which is called the Civil Day, as that made by the Sun from ſome Meridian to that Meridian again, is called the Natural Day.

And this Difference between the Sun's Day and Equinoctial Day is cauſed by the Obliquity of the Sun's Orbit; the Sun's apparent Motion being ſlower when in his *Apogæum*, than in his *Perigæum*.

PROB. XV.

To find the Latitude of any Star.

THIS is the Arch of a great Circle which paſſeth through the Poles of the Ecliptic and the Body of the Star, contained between the Ecliptic Line and the Center of the Star.

So to find the Latitude of *Lyra*; bring the Pole of the Ecliptic, which is next the Star, to the Meridian, and ſcrew the Quadrant of Altitude juſt over it; whence laying it over the Star to the Ecliptic, the Diſtance from the Star to the Ecliptic is 61° 20′ the Latitude.

PROB. XVI.

To find the Longitude of a Star.

THIS is that Part of the Ecliptic which is contained between the firſt Point of *Aries* and the Circle of Longitude which paſſeth from the Pole of the Ecliptic through the Center of the Star, and croſſeth the Ecliptic. So to find the Longitude of *Lyra* (the *Harp*) the Quadrant of Altitude placed over the Pole of the Ecliptic to extend over the Star, will cut the Ecliptic in 10° of *Capricorn*, which is 280° from the firſt Point of *Aries* = to the Longitude requir'd.

PROB. XVII.

To find the Right Aſcenſion of a Star.

BRING the Star to the Meridian, and that Circle will cut the Equinoctial in the right Aſcenſion, or Diſtance from the firſt Point of *Aries*.

PROB. XVIII.

To find the Declination of a Star.

THIS is done by bringing the Star to the Meridian, and then the Degrees in that Circle between the Star and the Equinoctial, is the Declination North or South.

EXAMPLES *of the four laſt* Problems *follow.*

STARS.	*Lat.*	*Longit.*	*Right Aſc.*	*Decl.*	*Mag.*
	° ′	° ′	° ′	° ′	
Lyra,	61 20	280 00	276 40	38 00 N.	1
Arcturus,	31 20	200 00	23 00	20 40	1
North Crown,	43 15	217 40	230 00	27 00	2
Pegaſus's Pinion, or *Marchab*	18 30	349 45	342 00	13 20	2
The Tip of the Wing,	12 20	4 42	357 40	13 12	2
Antinous's Breaſt,	21 00	296 30	293 45	00 00	3
Capella,	22 15	73 00	74 00	45 30	1
Cygnus, near the Neck,	53 45	318 00	302 00	36 30	1
Hercules's Left Shoulder,	39 00	234 30	241 45	19 30	3

Note, Sometimes it happeneth that the Stars are oppoſite to the Pole of the Ecliptic, ſo that you cannot take the Latitude or

Longitude with the Quadrant of Altitude, as being hinder'd by the Pole of the World. In this Caſe you may meaſure with a Thread from the Pole of the Ecliptic; and in Caſe of Latitude, meaſure the Thread on the Quadrant of Altitude.

PROB. XIX.

To find the Time when any Star comes to the Meridian (or Culminateth.)

FIRST, find the Sun's Place for the Day given; Secondly, Bring the Sun's Place in the Ecliptic to the Meridian; Thirdly, Put the Hour-Index to the upper 12; Fourthly, Turn the Globe about till the Star is under the Meridian; and then the Index will point at the Time required.

Thus for the *Bull's-Eye* will Culminate *Jan.* 1. 8^h. 50'. p.m. So *Syrius* will be South *Nov.* 4. at 5'. paſt 3 in the Morn. and *Virgin's-Spike*, *April* 1. 11^h. 55'.

PROB.

PROB. XX.

To find the Semi-diurnal Arch of any Star;

WHICH is the Difference in Time between its Riſing or Setting, and its being on the Meridian: For which, bring the Star to the Meridian; Secondly, The Hour-Index to 12; Thirdly, Turn the Globe till the Star come to the Horizon; and then the Hour-Index will ſhew the Anſwer: As in the *Examples* following.

PROB. XXI.

To find the Time of the Riſing of any Star;

YOU have nothing to do but ſubtract the Semi-diurnal Arch from the Time that the Star is South.

PROB. XXII.

To find the Time that any Star ſetteth.

ADD the Semi-diurnal Arch to the Time it is South, and the Sum is the Anſwer.

EXAMPLES *of theſe four laſt* Problems *take as follow.*

For Dec. 25.	*Semi-diurn. Arch.*	*Riſing.*	*Southing.*	*Setting, or under the Pole.*	*Magn.*
	h '		*h.*		
Near and under the Mouth of *Hydra*	5 50	7 10 *p.m.*	1.00 *m.*	6 50 *m.*	3
Hydra's Heart	5 30	8 45	2 15	7 45	1
Lion's Heart	7 15	7 35	2 50	10 05	1
Lion's Tail	7 30	9 00	4 30	12 00	1
Charles's heart	12 00	5 35	5 35	5 35 *p.m.*	2
Urſa Major, the End of his Tail	12 00	6 34	6 34	6 34	2
Arcturus, skirt of *Bootes*	8 00	11 00	7 00	3 00	1
North. Crown	8 48	11 32	8 20	5 08	2
Bull's-Eye	7 25	1 55	9 20 *p.m.*	4 45 *m.*	1
Goat, Capella	12 00	10 00 *m.*	10 00	10 00	1
Harp, Lyra	11 15	12 08	11 23 *m.*	10 38 *p.m.*	1
Orion's left Th.	5 15	4 45 *p.m.*	10 00 *p.m.*	3 15 *m.*	1
Pollux Neck	9 00	3 25	12 25 *m.*	9 35	2

Note, Where *p.m.* (*Afternoon*,) or *m.* (*Morning*) are not put down, they are the ſame with the laſt above.

Note, *2dly*, That there is *another Way of finding the Southing* of the Stars, *i. e.* ſubtract the Right Aſcenſion of the Sun from the Right Aſcenſion of the Star (adding 360°. if there be a Neceſſity) and the Remainder converted into Time, ſhews the Star's Southing.

EXAMPLE.

When will Arcturus *come to the Meridian, or South, the 25th Day of* December?

	°	h. '
Right Aſcenſion of *Arcturus*	213, or ——	14—12
To which add	360, or ——	24—00
	Sum	38—12
The Right Aſcenſion of the Sun deduct =	——	19—12
The Remainder is	——	19—00

Out of which take 12, and the Remainder is equal to 7 a-Clock; as in the Table laſt above, which is the Anſwer. And ſo of any other Star's Southing.

PROB. XXIII.

To find the Diſtance of two Stars.

TAKE the Quadrant of Altitude, and with that meaſure the Diſtance; and if it exceeds 90 Degrees, meaſure the reſt by the Quadrant of Altitude, or the Degrees of any great

Circle, as the Equinoctial, from the firſt Point of *Aries*.

EXAMPLE.

THUS between the *Harp* and *Arcturus* is 57°. 40′. and between the *Virgin's Spike* and *Aldebaran* (or *Bull's Eye*) is = 133 Degrees.

PROB. XXIV.

To find what Day of the Year any Star will be upon the South Part of the Meridian at 12 a-Clock at Night.

BRING the Star to the Meridian; then ſee what Degree of a Sign is cut by the Meridian in the Ecliptic; Thirdly, Look in the Horizon what Day of the Month ſtands againſt that Degree of that Sign: Which is the Anſwer. Thus,

The

	Place in the Ecliptic.	*South at 12 at night.*	*Mag.*
The bright Star under *Urſa Minor's* Neck,	17 20 ♏	*Oct.* 30.	2
Hercules's Head (*Nas Algietbi Arace*)	15 30 ♐	*Nov.* 25.	3
Draco, near his Eye,	26 40 ♐	*Dec.* 7.	3
Bootes Left Shoulder (*Ceginus*) ——	8 00 ♏	*Oct.* 20.	3
Lion's Back, ——.	13 00 ♍	*Aug.* 26.	2
Auriga's Right Shoulder, ——	25 00 ♊	*Jun.* 5.	2
Perſeus's Right Side (*Algenib*) ——	17 00 ♉	*Apr.* 27.	2
Whale's Mouth,	13 30 ♉	*Apr.* 23.	2
Andromeda's Head,	28 00 ♓	*Mar.* 7.	2
Cephus's Right Shoulder (*Alderab*)	16 30 ♒	*Jan.* 25.	3
Andromeda's Chain End, ——	9 30 ♓	*Feb.* 17.	3
Brighteſt in *Coma Berenices*, ——	3 30 ♎	*Sept.* 16.	3

PROB. XXV.

To find the Amplitude of any Star;

WHICH is the Number of Degrees in the Horizon that a Star riſeth or ſets from the Eaſt or Weſt Points towards the North or South: Bring the Star to the Horizon, and it will ſhew the Anſwer.

Thus *Fomahant* riſes 58°. from the Eaſt Southward, and ſets 58°. from the Weſt Southward.

PROB. XXVI.

To find how long any Star ſhines above the Horizon.

BRING the Star to the Eaſt Part of the Horizon; Secondly, Put the Index to 12; Thirdly, Turn the Globe Weſtward, till the Star comes to the Horizon Weſtward; and, Fourthly, Look at the Index; which will ſhew the Anſwer.

EXAMPLES *of the two laſt* Propoſitions.

	Time it is above the Horizon.		Ampl. of Riſing.		Mag.
	h.	'	°	'	
Fomahant, near *Piſces* (*Auſtrinus*'s Mouth)	5	20	58	00 S.	1
Antinous his Right Knee,	10	40	14	30 S.	3
Eagle's Tail, next the End,	14	30	22	30 N.	3
Middle of *Libra* (the *Ballance*)	10	40	14	30 S.	2
Canicula (biggeſt in the *Little Dog*)	13	00	10	00 N.	2
Caſtor's Forehead,	19	15	59	30 N.	2
Leo's Neck,	16	00	34	20 N.	2
Andromeda's Hip (*Mirach*)	20	00	63	10 N.	2

PROB. XXVII.

The Altitude of any Star being given, to find its Azimuth.

BRING the Degrees of the Star's Altitude (in the Quadrant of Altitude) to lie juſt over the Center of the Star, and then the graduated Edge will cut the Azimuth in the Horizon. So

	Altitude.	*Azimuth from the Eaſt.*	*Mag.*
Aldebaron (or South or Right Eye of the *Bull*)	51 30	66 00 S.	1
Orion's Right Shoulder (*Bed Algenſe*)	33 40	36 45 S.	2
Middle in *Urſa Major's* Tail,	45 00	39 30 N.	2
Caſſiopea's Right Armpit (*Scheder*)	48 30	34 20 N.	3
Aries his Head, between the Horns,	32 20	06 30 S.	3
Capricorn, (or *Sea-Goat*) between the Horns,	20 20	70 40 S.	3

PROB.

PROB. XXVIII.

The Altitude of any Star, and the Sun's Place in the Ecliptic given, to find the Hour of the Night.

BRING the Sun's Place to the Meridian (found as by *Prob.* I.) Secondly, Put the Hour-Index to 12 at Noon; Thirdly, Turn the Globe and Quadrant till the Altitude of the Star (upon the Quadrant of Altitude) fall juſt upon the Center of the Star; and then the Hour-Index will ſhew the Time of the Night.

Examples may be theſe that follow:

	Mag.	*Stars Alt.*	*Sun's Place.*	*Hour of the Night.*	*Days of Month.*
Great Dog's Right Foot,	2	20 30	10 ♎	4 45 *m.*	22 *Sept.*
Lepus's Left Side,	3	15 30	2 ♏	1 15 *m.*	14 *Oct.*
Canicula's Neck,	3	20 00	25 ♏	11 12 *p.m.*	6 *Nov.*
Virgo's Neck,	3	10 30	15 ♐	1 30 *m.*	26 *Nov.*
Aquila's Neck,	2	14 00	5 ♑	6 30 *p.m.*	16 *Dec.*
Aquarius's Water-pot [or Thumb,]	3	15 30	25 ♑	6 30 *p.m.*	4 *Jan.*
Nova Stella, in the *Whale's* Neck,	3	12 40	10 ♒	9 30 *p.m.*	19 *Jan.*
Loweſt of *Orion*'s Girdle,	2	28 20	2 ♓	9 40 *p.m.*	10 *Feb.*
Loweſt in *Urſa Major*'s Side, next the Middle of his Back,	2	71 00	22 ♓	1 00 *m.*	1 *Mar.*

PROB. XXIX.

To find the Acronical Riſing of any Star.

A STAR riſeth ſo, when it doth riſe at the Time when the Sun ſetteth, and doth conſequently ſhew when it may be the proper Time of obſerving any Star, ſo as to know its Altitude, Azimuth, Hour of the Night, thereby, &c. Thus:

STARS Riſing, and a little above the Horizon, at Sun-ſet, viz.

Jan. 10.	*Orion's* Right and Left Shoulder, Belt, and Right Thigh; *Caſtor* and *Pollux*; and *Urſa Major*, except its Tail.
Feb. 10.	Four in the *Hare*; the *Great* and *Little Dogs*; *Hydra's* Heart; *Lion's* Neck, Heart, and Back; *Cor Caroli*; *Coma Berenices*; *Bootes* Head and Left Shoulder.
Mar. 10.	Three in the *Ship*; *Lion's* Tail; *Virgo's* Neck; *Bootes* Right Shoulder and Knee; *Hercules* his Leg.

Apr. 10. *Corvus* 2; *Virgin*'s Spike; *Arcturus*; *Northern Crown*; three in *Hercules* his Body, and one in each Arm near the Body; *Lyra*; and four bright ones in the *Swan*.

May 10. The bright one in the Middle, and others about *Libra*'s *Ballance*; three near *Scorpio*'s Tail; *Hercules* his Head; *Swan*'s Head; and two bright ones in the *Eagle*'s Tail; *Andromeda*'s Chain End.

June 10. *Scorpio*'s Heart; a bright one in the *Eagle*'s Neck; five in the *Dolphin*; and four in *Andromeda*'s chained Hand.

July 10. Two in *Scorpio*'s Neck; three in *Sagittarius* his Left Hand, and three near his Neck; ſix bright ones in and near *Antinous* his Body.

Aug. 10. Two Horns of *Capricorn*; *Perſeus* his Right and Left Shoulder, his Side and Arm; *Pegaſus* his Wing and Scheat, or the bright one near his Tail; *Andromeda*'s Head, Hip, and Foot.

Sept. 10. Two in *Capricorn*'s Tail; *Aquarius* his Left Shoulder; that near his Right Shoulder, and Right Hand; *Ram*'s Head; *Perſeus* his Foot; *Hircus*, the *Goat*; and *Auriga*'s Right Shoulder.

Nov. 10. *Piſces Auſtrinus*; *Aquarius*'s Knee; two in the *Whale*'s Tail; the bright one near and above his Eye; the *Pleiades* in the *Bull*.

Dec. 10. The bright Star in the *Whale*'s Mouth; three near and under his Eye; *Aldebaron*; and *Auriga*'s Right Leg.

Note, That the Circumpolar Stars (or thoſe whoſe Declination is more than the Complement of the Latitude) never riſe nor ſet, but are diſtinguiſhed by being ſaid to be under the Pole, and above the Pole.

The foregoing *Table* is made by bringing the Place of the Sun in the Ecliptic to the Horizon in the Weſt, and then the Stars mention'd will be in or a little above the Horizon in the Eaſt.

PROB. XXX.

AND becauſe I would endeavour to help the Reader to know the Stars, I will give him the following Table of the circumpolar Stars of moſt Note, (with their Declination) the Time when they are Eaſtward from the North Part of the Meridian at 45 Degrees of Altitude, and are aſcending toward the South Part, or Zenith, at Sun-ſet. Degrees 90 leſs, the Latitude 51.32. reſts the Compl. Lat. 38°. 28′.

	Declin.		*Mag.*	*Alt.* 45°. *at Sun-ſet.*
Swan, near the Neck,	38	30	3	*July* 14.
Ditto, near the Tail,	43	40	2	*Ditto.*
Ditto, in the Right Wing,	43	50	3	*Ditto.*
Hercules's Foot,	46	00	3	*May* 24.
Bootes's Head,	41	00	3	*Apr.* 13.
Left Shoulder,	38	40	3	*Ditto.*
Cor Caroli,	40	00	2	*Apr.* 3.
Auriga's Right Shoulder,	44	50	2	*Jan.* 15.
His beloved *Hircus*,	45	40	1	*Jan.* 8.
Perſeus's Right Knee,	38	30	3	*Dec.* 30.

	Declin.	*Mag.*	*Alt. 45°. at Sun-ſet.*
Perſeus's Right Side,	49 00	2	*Dec.* 15.
His Right Arm,	51 00	3	*Dec.* 8.
His Left Arm,	43 26	3	*Dec.* 14.
Andromeda's Foot, (*Alamac*)	40 30	2	*Dec.* 5.
End of her Chain,	43 20	3	*Sept.* 18.
Cepheus's Right Shoulder,	61 00	3	*July* 2.
His Belt,	68 40	3	*June* 22.
Two in *Draco*'s Head,	51 00	3	*May* 18.
Four in his Body, 58 to	66 00	3	*Apr.* 25.
Three in *Urſa Major*'s Tail, 51 to ——	57 30	2	*Mar.* 28.
Four in his Left Side, 55,20 to ——	63 30	2	*Feb.* 5.
Five in *Caſſiopea*, 54 30 to ——	62 00	3	*Oct.* 15.
Urſa Minor, under his Neck, ——	75 00	2	*Mar.* 25.
One under the laſt,	73 00	3	*Apr.* 5.

Two in his Body, and two in his Tail, *Declin.* 76 to 86 ; *Magn.* 4, 5, 6 ; *Alt. Apr.* 9.

End of his Tail, or *Pole-Star*, *Decl.* 87 27 ; *Magn.* 2 ; *Sept.* 12. at 51.30. *Alt.*

To make the foregoing *Table*; lay 45 Degrees of the Quadrant of Altitude upon the Center of the Star; then ſee what Degrees of the Ecliptic are cut by the Horizon Weſtward, and find thoſe Degrees in the Scale of the Horizon; and right againſt that ſtands the Day of the Month.

Note, That the End of Twylight, or Time of the Stars appearing, is found for the reſpective Days in the laſt *Table* by the Rules under *Prob.* IX. foregoing: The Stars of the firſt, ſecond and third Magnitude appear when the Sun is 12, 13, and 14 Degrees below the Horizon; and thoſe of the fourth, fifth, and ſixth Magnitude, when the Sun is 15, 16, and 17 Degrees below the Horizon.

PROB. XXXI.

To find the Latitude of a Place when at Sea, by a Star, having its Altitude, Azimuth, and Declination given.

FIRST, Put the Degrees of the Altitude on the Braſs Meridian to the Horizon; Secondly, Screw the Quadrant of Altitude upon the Complement of the Altitude; Thirdly, Bring the Quadrant of Altitude to the Azimuth in the Horizon from the North Point thereof, and there keep it; Fourthly, Turn the Globe till the Degrees of Declination, reckoned upon the Equinoctial Colure from the Equinoctial, cut the Quadrant of Altitude, which will be in the Latitude required.

EXAMPLE.

Andromeda's Head, Altitude = 55°; to which I elevate the Pole above the Horizon; Secondly, I ſcrew the Quadrant of Altitude to the Complement thereof, 35°; Thirdly, I put the Quadrant of Altitude to the Azimuth in the Horizon, *i.e.* to 100°. 30′. from the North; Fourthly, I turn the Globe till 27° = (the Declination of *Andromeda*'s Head) upon the Equinoctial Colure cut the Quadrant of Altitude, which it doth in 40°. 30′. = the Latitude ſought.

So likewiſe the Latitude is found by theſe Stars:

	Altit.	*Azim.*	*Declin.*	*Latit.*
	° ′	° ′	° ′	° ′
Procyon, or *Little Dog*,	35 00	98 30	05 45	20 30
Arcturus,	45 30	112 00	20 40	45 30
Bull's Eye, or Forehead, (*Aldebaron*)	61 00	135 00	15 30	37 30

The Latitude is moſt eaſily found by the Terreſtrial Globe for any Place at Land; but the Rule above is for thoſe at Sea.

PROB. XXXII.

A moſt eaſy and natural Way of finding the Hour Diſtances on an Horizontal Dial for any Latitude.

HAVING rectify'd the Globe to the Latitude, bring 15°. of the Equinoctial to the Meridian, and then the Equinoctial Colure will cut the Horizon in 11°. 51′. = the Diſtance of the Hours of 11 and 1 from the Meridian.

In like manner, if you bring 30°, 45°, 60°, and 75°. of the Equinoctial to the Meridian, then the Equinoctial Colure will cut reſpectively in the Horizon, the Hour Diſtances from the Meridian (or 12 a-Clock Hour-Line) of the

Dial 11°. 51′.; 24°. 19′.; 38°. 4′.; 53°. 35′.; and 71°. 6′.; as in the following Table.

Degrees of Equin. at Merid.	*Hour Diſtances cut by the Colure.*	*For the Hours of*
	°	
15	11—51	11 & 1
30	24—19	10 & 2
45	38—04	9 & 3
60	53—35	8 & 4
75	71—06	7 & 5
90	90—00	6 & 6

And the Hour-Diſtances of 5 and 4 in the Morning, and 7 and 8 in the Afternoon are the ſame as thoſe before the Hour-Line of and next to that of 6. And the Height of the Stile, or Gnomen, or Cock, is the Latitude of the Place; and ſo your Dial is finiſhed.

PROB. XXXIII.

To find the Hour-Diſtances upon the Erect Direct South Dial.

THIS is done as the laſt: But only elevate the Globe to 38.28, *&c.* the Complement of the Latitude, inſtead of the Latitude 51.52: For, bringing 15°. of the Equinoctial to the Meridian, the ſaid Colure will cut in the Horizon 90°. 27'.; and ſo of the reſt. And the Angle of the Stile muſt be 38°. 28'. See the following Table.

Degrees of Equin. at Merid.	*Hour-Diſtances cut by the Colure.*	*For the Hours of*
	o	
15	09—27	11 & 1
30	19—45	10 & 2
45	31—53	9 & 3
60	47—09	8 & 4
75	66—42	7 & 5
90	90—90	6 & 6

Note, The erect direct North Dial hath only the 6 a-Clock Hour-Lines, and the 2 before and 2 after 6 in the Morning, and the ſame in the Afternoon, of like Diſtance with the laſt Dial. And the Stile is the ſame, only placed above the Hour-Line of 6, with the Angle downward to the Center of the Dial.

But the beſt Way of making Eaſt, and Weſt, and Decliners, not being by the Globe, I ſhall ſay no farther of them in this Place, but proceed.

SECT. II.

Aſtronomical PROBLEMS, *relating to the* MOON *chiefly*; *containing* RULES *for Computing* Time: *Of Uſe to thoſe who would make* Almanacks *for any Year to come. In a very eaſy Method, and more Various and New than any one has done before.*

PROB. I.

To find the Golden Number for any Year (or Cycle of the Moon.

THIS is a Cycle, or Revolution of nineteen Years; in which Time, the Fulls, Changes, and Eclipſes of the Moon were reckoned to return in the ſame Order, or near it.

RULE.

Add 1 to the Year of our Lord, and divide the Sum by 19, and the Remainder is the Golden Number: And if nothing remain, that Year is the laſt, or 19th of the Cycle.

Note, The Reaſon you add 1, is, becauſe 1 Year of the Cycle was gone when the Year of our Lord commenced.

EXAMPLE.

What is the Golden Number for the Year 1726? *the Year I wrote this Part.*

1726
more 1
19)=1727(90
17 reſts. The Anſwer.

PROB. II.

To find the Cycle of the Sun.

THIS is a Revolution of 28 Years; in which Time the Leap Years and Dominical Letter come again in the ſame Order.

RULE.

RULE.

Add 9 to the Year of our Lord (becauſe 9 Years of this Cycle was gone when the Year, or Æra, of our Saviour's Incarnation did begin) and divide the Sum by 28, and the Remainder is the Anſwer. Or if 0 remain, that Year is the laſt, or 28th, of the Cycle.

EXAMPLE.

To find the Cycle of the Sun for 1726.

```
        1726
   more    9
   ---------
  28)=1735(61
          55
          27 = the Anſwer.
```

PROB. III.

To find the Epact for any Year.

THIS is the 11 Days Difference between the Solar Year of 365 Days, and the Lunar of 354.

RULE.

Divide the Golden Number by 3, add 10 times the Remainder to the Golden Number, and the Sum is the Epact.

EXAMPLE.

What is the Epact for the Year of our Lord 1726?

See the Operation following.

The Golden Number for this Year 1726. is ſound 17; as above.

3)17(5
2
Multiply by 10

20 more 17 is = 37, leſs 30, reſts 7 = the Anſwer.

Or thus: I multiply the Golden Number by 11, and divide the Product by 30, and the Remainder is 7, the Epact, as before.

PROB. IV.

To find how many Years any Year is from Leap Year.

THE *Romans* called Leap Year *Biſſextile*, becauſe they put the odd Day, gained by four times ſix Hours (the Year being 365 Days and 6 Hours) after the 6th of *March*, reckoning that Day twice. But we place the Day after the 28th of *February*.

RULE.

Divide the Year by 4, what's left will be,
For Leap Year 0; Years paſt, 1, 2, or 3.

EXAMPLE.

For,

4)1726(431
12
6
reſts 2, or the 2d after Leap Year.

PROB. V.

To find the Dominical (*or* Sunday) *Letter*.

RULE.

Divide the Sum of the Year of our Lord; a 4th thereof and 4 by 7; ſubtract what remains from 7; and that laſt Remainder is the Letter required: Reckoning 1 = A, 2 = B, 3 = C, 4 = D, 5 = E, 6 = F, and 7 = G.

EXAMPLE.

What is the Dominical Letter for the Year 1726?

1726 = the Year.
431 = its 4th.
4
7)2161 = Sum (308
61
5 reſts, and 7 leſs 5 = 2, or B.

But *Note*, That in Leap Year there are two *Sunday*-Letters; the one found as above, uſed all the Year after St. *Matthias*'s Day, *February* 24. to which Time, from the firſt of *January*, the next Letter following is inſerted in the Calendar: as in the two laſt Leap Years. The Dominical Letter for 1720. is found, by the Rule above, to be B; uſed from St. *Matthias*'s Day to the End of the Year; and the Letter next in the Alphabet (or C) is uſed for the *Sunday*-Letter from the 1ſt of *January* to the 24th of *February* (or St. *Matthias*'s Day.) So alſo in 1724. the Dominical Letter, found as above, is D; and from the 1ſt of *January* to the 24th of *February* it is E. The *Sunday*-Letters being reckon'd backward always in this Caſe.

Note alſo, That a 4th is added for the Leap Years; and 4, becauſe ſo many of this Cycle of the Dominical Letter was gone when the Year of our Lord commenced.

PROB. VI.

To find the Moon's Age at any Time.

RULE.

Add the Epact, the Day of the Month, and Months from *March*, together, (including *March* and the Month you reckon to) and the Sum is the Moon's Age. If that amount to 30 or 60, deduct them.

EXAMPLE.

I would know the Moon's Age the Day that I am writing this, which is *Auguſt* 30. 1727.

18 = the Epact.
6 = Months from *March* incluſive.
30 = Day of the Month.

54 Sum, leſs 30 = 24 from 30, the Day, reſts 6, the Age.

But *Note*, That from *January* the 1ſt to *March* the 1ſt, you muſt uſe the Epact for the Year next preceding.

PROB. VII.

To find the Hour and Minute when the Moon comes to the Meridian.

RULE.

Multiply the Age by 4, and divide the Product by 5, and the Quotient is the Hour, and the Remainder is ſo many times 12 Minutes.

EXAMPLE.

To know when the Moon comes to the South when it is ſix Days old.

```
     6
Multiply by 4
   ------
   5)24(4
   ------
      4 reſts.
     12 mult.
   ------
     48 Minutes.
```

So 48 Minutes paſt 4 is the Anſwer.

PROB. VIII.

To find what Day of the Month Shrove-Sunday *is, and conſequently the Day of all the Moveable Feaſts.*

BY *Shrovetide* is meant Confeſſion-Time. *Shrove-Sunday* in the Calendar is called *Quinquageſima*, as being fifty Days before *Eaſter*.

RULE.

Shrove-Sunday, upon which the reſt depend, is always the firſt *Sunday* after the ſecond Change of the Moon which happeneth after *New-Year's-Day.* And if that Day of the ſecond Change be *Sunday* (as it was *Anno* 1716, 1717, 1720, 1723, and 1726. then that *Sunday* is *Shrove-Sunday*.

EXAMPLE.

What Day of the Month was Shrove-Sunday *in the Year* 1725?

RULE.

In this Caſe you muſt always uſe the Epact for the Year before, whereby, &c. as under *Prob.*

Prob. VI. having found the Moon's Age, ſuppoſe *Feb.* 15. to be 13 Days old, I run back and find the Day of the ſecond Change was *February* the 2d; and *February* (as by the *Rule* in the next *Problem*) beginning with D, and the Dominical Letter for that Year (as by *Prob.* V.) being C; therefore D being the firſt, D is the eighth Day, and of Conſequence C is the ſeventh of *February*; which being the firſt *Sunday* after the ſecond Change, is *Shrove-Sunday.* From which the other Moveable Feaſts are found thus:

Shrove-Sunday, being found as above, -	*Feb.* 7.
Quadrageſima, or firſt *Sunday* in *Lent*, muſt be — —	*Feb.* 14.
Eaſter-Day, being ſeven Weeks after *Shrove-Sunday*, muſt be —	*Mar.* 28.
Eaſter-Term, beginning a Fortnight after *Eaſter Wedneſday*, —	*Apr.* 14.
Rogation-Sunday, being 5 Weeks after *Eaſter*, — —	*May* 2.
Aſcenſion-Day, being 40 Days after *Eaſter*, is — —	*May* 6.
Eaſter-Term ends the *Monday* after *Aſcenſion-Day*, —	*May* 10.

Whitſunday,

Whitſunday, ſeven Weeks after *Eaſter*, muſt be	*May* 16.
Trinity-Sunday, the next after *Whitſunday*,	*May* 23.

Trinity-Term begins *Friday* after *Trinity-Sunday*, and ends *Wedneſday* a Fortnight afterward.

And the Beginning and End of *Hilary* and *Michaelmas Terms* are fixed.

Note, That *Septuageſima* is a Fortnight, and *Sexageſima* a Week before *Shrove-Sunday*.

Advent-Sunday is always that next the 30th of *November*, whether before or after it.

Epiphany is reckon'd among the moveable Feaſts; but it is always the 6th of *January*.

Note alſo, I have by me near twenty Years Almanacks, many of different Authors; and I find the Rule given by Mr. *Cole* in his *Engliſh Dictionary*, to be erroneous, particularly for 1709. And the Rule given in the *Common-Prayer-Book* for finding *Eaſter* is wrong, for the following Years;

1708,

1708, 1709, 1711,
1712, 1715, 1718,
1721, 1722, 1724,
1725, and 1727.

But my own Rule above, is right for all thoſe Years; and I doubt not but that it will be found genuine for all Years paſt or to come, and 'tis very eaſy; and which therefore ought to be inſerted in the Room of the falſe *Rule*.

PROB. IX.

To find at any Time what Day of the Week any Day of the Month was, or will be, and the contrary.

RULE.

To do this, it is neceſſary to keep in mind the Letter that every Month (as touching the Days of the Week) begins with, and alſo the Dominical Letter for the Year. It may be of uſe as to the firſt, to get theſe two Lines by Heart.

Jan. Feb. March, April, May, June,
A- Dieu, Dear George, Be Evermore
July, Auguſt, Sept. Oct. Novemb. Decemb.
Good Clement's Friend; A Dying Flower!

EXAMPLE.

I would know what Day of the Week the 24th of *June* (or *Midſummer-Day*) was in the Year 1664.

The Dominical Letter for that Year, found as by *Prob.* V. above, was B; Now by the ſaid Verſe, *June* beginning with E; I ſay, E 1, E 8, E 15, E 22, F 23, G 24, A 25, B (which is the *Lord's-Day*) 26; therefore the 24, or Anſwer, is *Friday*: For if *Sunday* be 26, *Saturday* is 25, and *Friday* 24.

On the contrary, To find what Day of the Month the laſt *Friday* in *June* 1664. was; Firſt, B is found to be the Dominical Letter, as above, and E the firſt of the Month of *June*; I go forward till I come to *Sunday*, as *e* 1, *f* 2, *g* 3, *a* 4, and *b* 5: Now *Sunday* being the 5th, *Friday* muſt be the 3d of *June*, and *Friday* 10, *Friday* 17, and *Friday* 24; ſo the Anſwer is the 24th of *June*, and proves the above Example.

PROB. X.

To find by a Sun-dial the true Time of the Night by the Shade of the Moon.

RULE.

By the *Prob.* above, &c. find when the Moon comes to the South; Secondly, If the Shadow falls in the Forenoon-hours, deduct what the Shadow wants of 12 from the Time that the Moon comes to the Meridian, and the Remainder is the Hour of the Night. Or if the Shade falls in the Afternoon-hours, add what it is paſt 12 by the Dial, to the Time the Moon was South.

EXAMPLE.

Suppoſe the Moon is South 24 Min. paſt 10 ſome Day; I look at my Dial, and find it 11 a-Clock; therefore I take 1 from 10 *h.* 24′. and the reſt is 9 *h.* 24′. the Hour required.

Or the ſame Night, ſuppoſe I find the Hour on my Dial at 1, I may then conclude that the Moon is one Hour paſt the Meridian; ſo I add 1 to 10 *h.* 24′. and the Sum is 11 *h.* 24′. the true Time of the Night.

PROB. XI.

To find the Time of the Moon's Riſing and Setting.

I. IT muſt be obſerved, That at every New Moon the Sun and Moon are in or near the ſame Degree of the ſame Sign.

II. That a Sign is 30 Degrees of the Ecliptic, and each Degree 60 Minutes.

III. That the Characters of the 12 Signs, and the Time that the Sun enters into each, are,

♈ *Aries*, *March* 10.
♉ *Taurus*, *April* 10.
♊ *Gemini*, *May* 11.
♋ *Cancer*, *June* 11.
♌ *Leo*, *July* 13.
♍ *Virgo*, *Aug.* 13.
♎ *Libra*, *Sept.* 13.
♏ *Scorpio*, *Octob.* 13.
♐ *Sagittarius*, *Nov.* 12.

♑ *Capricorn*, *Dec.* 11.

♒ *Aquarius*, *Jan.* 10.

♓ *Piſces*, *Feb.* 8.

IV. That the Sun's Progreſs through theſe twelve Signs is once in twelve Months; but the Moon's in leſs than a Month.

V. That the daily Motion of the Moon is about 13 Degrees, 11 Minutes.

EXAMPLE.

To know when the Moon did ſet the 14th Day of May, 1625.

By *Prob.* VI. the Moon changed *May* the 1ſt, when the Sun's Place in the Ecliptic, by the Signs above, and reckoning every Day a Degree, was 21 Degrees of *Taurus*. From which Place to the 14th of *May* aforeſaid (or when the Moon is thirteen Days old) I find by multiplying 13°. 11′. by the 13 Days, 5 *ſign.* 21°. 23′.; which added to 21 Degrees of *Taurus*, gives 6 *ſ.* 12°. 23′. = the Moon's Place the 14th of *May* aforeſaid: Which by the foregoing

Account of Signs, is 13 Degrees of the Sign *Scorpio.*

Then by conſidering the Time the Sun hath Ingreſs into each Sign, it will appear that the Sun is in that Sign and Degree the 26th of *October*; and by the Globe, Quadrant, or Tables of the Sun's Riſing and Setting on that 26th of *October*, the Sun ſets 4*h*. 36'.; which adding to the Moon's Southing the ſaid 14th of *May*, *viz.* to 10*h*. 24'. [*See* Prob. VI, VII, *and* X.] gives the Sum 3 in the Morning (deducting 12 from the Sum) when the Moon ſets the 14th Day of *May*, 1725. And if we deduct 4*h*. 36'. (when the Sun ſets) from 10*h*. 24'. when the Moon is South, there will remain 5*h*. 48'. when the Moon riſeth the ſaid 14th of *May* 1725. As by the following Operation:

	h.
Moon South, ——	10—24
Sun ſets (add) ——	04—36
Sum (Moon ſets) = —	03—00
Or if you deduct the 2d Number from the 1ſt, the Rem. gives the Moon's Riſing, ——	05—48

PROB. XII.

To find the Time of High Water at London-Bridge.

SOME give this RULE, To add three Hours to the Time of the Moon's Southing; but that will only hold exactly true for the Day of the New or Full Moon, when the Moon is always South at 12 a-Clock.

There are two ſhort Tables which have been publiſhed two or three Years in Mr. *Partridge's* and Mr. *Parker's* Almanacks; but ſince they have not ſhewed the making thereof, I ſhall omit them, and inſert a Table of my own Contrivance, as follows; and ſhew the Calculation both of the Table of the Moon's Southing, and of the High Water at *London-Bridge*.

A TABLE *of the* MOON's *Southing, and High-Water.*

	Moon South.	*High Water.*
	h. Min.	*h. Min.*
A New or Full Moon,	0—00	3—00
1 Day after,	0—48	3—48
2 ——	1—36	4—21
3 —— ——	2—05	4—45
4 ——	3—12	5—27
5 —— ——	4—00	6—00
6 —— —	4—48	6—33
7 —— ——	5—36	7—06
At the firſt and ſecond Quarters =	6—00	07—30
1 Day after, —	6—48	08—18
2 ——	7—36	09—21
3 —— ——	8—24	10—24
4 ——	09—12	11—27
5 ——	10—00	12—30
6 —— ——	10—48	01—33
7 ——	11—36	02—36

CONSTRUCTION *of the foregoing* TABLE.

THE Moon coming to the Meridian every Day 48 Minutes later for a Week after the New and Full, and after the firſt and ſecond Quarter, I therefore make the Table of her Southing by the continual Addition of Forty-eight Minutes.

Then for High Water, I add three Hours for one Day after Full or Change, to the Moon's Southing that Day; for two Days after, I add three Hours wanting a Quarter, to the Time the Moon is South that Day; for three Days, I add three Hours wanting two Quarters, *&c.* adding a Quarter of an Hour leſs every Day to the Time the Moon is South that Day.

Secondly, For one Day after the firſt and ſecond Quarters, I add 1 *h.* 30 *min.* to 6.48, the Time the Moon is on the Meridian that Day, *&c.* adding for every Day fifteen Minutes more than the Day before, from the firſt Day, gives the ſeveral Times of High Water in the Column next the Right Hand.

USE of the TABLE.

This is ſo plain, that it needs no Example; for it ſhews, that three Days after the New or Full Moon, it is South 24 Minutes after two; and that it is High Water that Day 54 Minutes paſt 4.

So alſo, That two Days after the Firſt or Second Quarters, the Moon is South 36 Minutes paſt 7, and that High Water is 21 Minutes paſt 9.

There is a pretty Mathematical Way contriv'd by Mr. *Philips*, publiſhed in *Philoſophical Tranſactions*, N° 34 for finding the Tides, thus:

1. He divides the Periphery of a Circle into twelve equal Parts, or Hours, according to the Moon's Motion from New to Full.

2. He divides the Diameter of that Circle into 90 Parts, or Minutes, according to the Time of the Difference of Tides, after the Moon's Southing, between the New and Full Moon, and the Firſt and Second Quarters,

which is an Hour and a Half;) ſo that 1, 2, 3, *&c.* are the Hours round the Ambit from the End of the Diameter next the Right Hand, where ſtands 12; and at the End, toward the Left Hand, 6; and the Minutes from the Right Hand towards the Left of the Diameter, 1 to 90.

3. He makes Right Lines croſs the Diameter from the Hours above the Diameter to the Hours below; as from 10 to 2, 9 to 3, 11 to 1, *&c.*

4. He reckons the Time of the Moon's coming to the South in the Circumference, and where the Perpendicular Lines cut the Diameter, it ſhews what Minutes muſt be abated from the Time of High Water in the New and Full, or added for the Quarters to the Difference between the Moon's Southing and High Water, at the Firſt and Second Quarters.

The Learned and moſt Celebrated Sir *Iſaac Newton* fully accounts for the Tides in his Theory thereof; and ſays, That the Spring-Tides about the New and Full Moons are cauſed by the attractive Power of the Sun being added to that of the Moon.

Note, The Spring-Tides are three Days before, and ſtill higher, three after the New and Full Moon ; and all the other Tides about the Quadratures, *&c.* are called Neip-Tides.

SECT. III.

The Deſcription *and* Uſe *of the* TERRESTRIAL GLOBE.

I. THIS is a Repreſentation of the Earth and Water on the Convexity of a Sphere or Globe, near unto which Figure the Terraqueous Body is found to be.

II. The *Earth* is diſtinguiſh'd by

1. *Continents*,

2. *Iſlands*,

3. *Peninſula's*,

4. *Iſthmus's*,

5. *Promontories*, and

6. *Capes*.

III. A *Continent* is where many Kingdoms and Territories of Princes are contiguous, without being ſeparated by an *Ocean*. According to which, *Europe*, *Aſia*, and *Africa* are but one Continent, and *America* is another. The *Ocean* and *Seas* that ſurround them will be mention'd under the IXth and Xth Heads following.

IV. An *Iſland* is a Quantity of Land wholly environ'd by an *Ocean*, *Sea*, *&c.* as *Great Britain* and *Ireland*, bounded by the *Weſtern* and *Northern Oceans*, the *North Sea*, the *Engliſh Chanel*, and St. *George's Channel*; alſo *Cyprus*, *Candia*, *Sicily*, *Sardinia*, *Minorca*, *Majorca*, and *Yvica*, all in the *Mediterranean Sea*. You have alſo *Madagaſcar*, the *Ladrone*, *Philippian*, *Caribbee*, and Hundreds of other *Iſlands*.

V. *A Peninſula* is almoſt an *Iſland*, being only joined to other Land in ſome ſmall Part; the moſt conſiderable of which is *Africa*, *North* and *South America*, *Spain*, *Italy*, *&c.* And that Neck of Land that makes it a *Peninſula*, and not an *Iſland*, is called,

VI. An *Iſthmus*.

VII. A *Promontory* is a mountainous Part of Land which extends a conſiderable Way into Sea; the Extremity of which is called

VIII. A *Cape*; as that of *Good-Hope* in the South of *Africa*, *Comorin* in the South of *India*, *Cape Horn* in *Terra del Fuego*, &c.

IX. The *Water* is diſtinguiſh'd by

1. *Oceans*,
2. *Gulphs*,
3. *Streights*,
4. *Lakes*,
5. *Bays*, and
6. *Rivers*.

X. An *Ocean* is a vaſt Quantity of Water, which commonly boundeth ſome of the four Quarters of the World; as the *Weſtern* and

Atlantic Oceans, which bound *Europe* and *Africa* towards the Weſt; *Northern* and *Southern Ocean*, which is their Bounds toward the North and South; *Indian Ocean*, on the South of *India*; *Eaſtern Ocean*, to the *Eaſt* of *China*; and the *Pacific Ocean*, to the South Weſt of *America*, &c.

XI. A *Sea* is commonly leſs than an *Ocean*, and hath Communication therewith; as the *Mediterranean*, which parts *Europe* from *Africa*; the *Ethiopian Sea*, South-Weſt of *Africa*; the *Baltic Sea*, which parts *Muſcovy*, *Poland*, and *Germany* from *Sweden*; the *Red Sea*, between *Aſia* and *Africa*, &c.

XII. *Gulph* is Water ſhooting up into the Land from a *Sea*; as the *Gulphs* of *Venice*, *Perſia*, *Baſſora*, *Finland*, &c.

XIII. A *Streight* is a narrow Paſſage of Water between an *Ocean* and a *Sea*; as *Gibraltar*, *Sundy*, *Baſſora*, and *Babelmandel*, or thoſe into the *Red-Sea*, and many others. It makes a *Sea* differ from a *Lake* by Water, as an *Iſthmus* does a *Peninſula* from an *Iſland* by Land.

XIV. A *Lake* is every Way encompaſſed by Land, having no viſible Communication with the *Ocean*, &c. The moſt conſiderable are, the *Caſpian Sea*, the *Lake Leman* (or of *Geneva*,) *Niger* in *Africa*, the *White Lake* in *Ruſſia*, &c.

XV. A *Bay* is as if the Land received or embraced a conſiderable Part of the *Sea* between its two Arms. The moſt conſiderable Bays are thoſe of *Panama* in the *South-Sea*, *Biſcay* (made by the Coaſts of *France* and *Spain*,) of *Bothnia* in the *Baltic* Sea, of *Bengal* in *Eaſt India*, of *Nanking* in *China*, &c.

XVI. A *River* commonly ariſeth in ſome mountainous Part of the Earth, and makes its Way (the greateſt ſome thouſands of Miles) into an *Ocean* or *Sea*, &c. and in its Courſe many leſſer Rivers fall in it. The moſt conſiderable are, *La Plata* (which I take to be the biggeſt in the World) in *South America*; *Euphrates*, a large River riſing near Mount *Ararat* in *Armenia*, and falls into the Gulph of *Baſſora*, which parts *Perſia* and *Arabia*; *Danaw*, or *Danube*, which riſes at *Furſtenburg* in the Circle of *Suabia*, and falls into the *Euxine* (or *Black*) *Sea*; *Niger*, in *Africa*, which riſes in the Lake *Niger*, and falls with the River *Gambia* into the *Atlantic Ocean* near Cape *Verde*; *Nyle* riſes in the Lake of *Tzana* in *Abyſſina* in *Africa*, not far from the *Red Sea*, and with the great River *Nubia* (meeting at *Tuo*) falls into the *Mediterranean* Sea near *Alexandria* in *Egypt*; *Wolga* riſes near *Kaſan* in *Muſcovy*, and falls into the *Caſpian* Sea near *Aſtracan*; *Ganges* riſes out of the Mount *Caucaſus* near *Siba*, in the *Mogul's* Empire, and falls into the Bay of *Bengal* near *Sundiva*. I will add the River *Thames*, which, tho' ſhort, is, like the People, profound, gentle, and ſilent; it carries perhaps more Ships and more Riches to that incomparable City, *London*, than can be ſaid of all theſe other Rivers put together to all Places.

XVII. *The Length of theſe Rivers I have carefully meaſured thus:*

	Engliſh Miles.
La Plata	1640
Euphrates	910
Danube	1400
Niger	2450
Nyle	1470
Wolga	980
Ganges	940
Thames	200 near.

But *Note*, That the River *La Plata* is (near the Mouth, where it falls into the *Southern Ocean*) about 240 Miles broad.

XVIII. And by the foregoing Deſcriptions, it ſeems, That

In Land	*In Water*
A *Continent* may be compared	to an *Ocean*.
A *Large Empire* — —	to a *Sea*.
A *Peninſula* — — —	to a *Gulph*.
An *Iſthmus* — — —	to a *Streight*.
An *Iſland* — — — —	to a *Lake*; and
A *Promontory* — —	to a *Bay*.

XIX. But there are many other very conſiderable Rivers in the World, beſides thoſe mention'd above; as,

In EUROPE.

In FRANCE.

The *Seyne*, the *Loyre*, the *Roan*, the *Garone*.

In the NETHERLANDS.

The *Maes*, the *Rhine*, *Scheld*, and *Senne*.

In SPAIN.

The *Duero* and *Ebro*.

In PORTUGAL.

The *Tajo* and *Guadiano*.

In ITALY.

The *Tyber*, the *Po*, and the *Arno*.

In GERMANY.

The *Weſer*, *Elbe*, (beſides the *Danube* and ſmall ones.)

In TURKEY *in* EUROPE.

The *Save*, *Morava*, *Alauta*, and the *Pruth*.

In POLAND.

The *Nieper* or *Boriſthenes*, *Weſel*, and the *Bug*.

In MUSCOVY.

The *Oby*, *Tanais*, *Deeſna*, *Dwina*, and *Oskoll*.

In SWEDEN.

The *Dalecarlus*, *Eſſinan*, *Indais*, &c.

In ASIA.

In CHINA *and* ARABIA.

The *Croceus*, *Kiang*, and *Tigris*.

In AFRICA.

The *Zambre* and the *Zaire*.

In AMERICA.

The River of *Amazons*, *Oroonoko*, and *Canada*.

XX. But I ſhall give a more particular Account of the Parts of the Earth, and ſhew what Countries are contained in each of the four Quarters of the World, with their chief Cities or Towns, and their Latitude and Longitude, when I come to ſhew the Uſe of Maps; no Globes being large enough to have all the Places Situation diſtinguiſhed: Tho' by them we can beſt account for the Situation of the Inhabitants in general; which are,

1. Thoſe that live in the ſame Latitude, and are of the ſame Side of the Equator, but are 180 Degrees Difference in Longitude, are called *Perieſi*: As *London* being in the Latitude of 51.32. and Longitude 27°. if to 27 I add 180, it makes 207; ſo that *London* is in *Perieſi* with that Place (which is Sea) that hath Latitude 51°. 32′. and Longitude 207°. So alſo

The *Havana*, in the Iſland *Cuba* in *America*, is *Perieſi* with *Bengal* in the *Eaſt Indies*.

Barbados, in the *Weſt Indies*, is *Perieſi* with *Manila*, one of the *Philippine* Iſlands.

2. Thoſe that have the ſame Number of Degrees of Latitude and Longitude, but are the one in North, the other South Latitude, are ſaid to be ſituate in *Antieſi*: As *London*, 51°. 32′. Latitude, and 27°. Longitude, is *Antieſi* with a Place at Sea, which is about 20°. near S. W. from the Cape of *Good-Hope*. So alſo is

The Cape of *Good-Hope* with (near) *Syracuſa* in *Sicily*, *&c.*

The Iſland *Sancta Helena* with (near) *Godia* in *Negroland*, *Africa.*

3. Thoſe Inhabitants who have the ſame Degrees of Latitude, but are the one South, the other North, and have 180 Degrees Difference of Longitude, are *Antipedes*: As *London* with a Place which is at Sea, 11°. 30′. from *New Zealand* Southward, which is about 44 Degrees Eaſtward from the Middle of *New Holland*, in the South Part of *Eaſt India*, in the Great *Southern Ocean*.

XXI. *The Circles and Parts of this* GLOBE *are,*

The Meridian, Horizon, Equator, Ecliptic, the two Tropics, and two Polar (or *Artic* and *Antartic*) Circles; whoſe Deſcriptions and Diſtances from one another upon the Globe are as the Deſcription of the Celeſtial Globe: Only it may here be farther added, That the Equinoctial on the Celeſtial, is called the Equator on the Terreſtrial Globe. On which Globe are to be obſerved five Zones, the Dimenſions whereof, with the Diſtinction of Inhabitants, and their Shadows, are thus:

No.	*Names of the Zones.*	*Extent*	*Dimenſions.*	*Shad. caſt at Noon.*	*Inhabitants called*
1	Torrid	Betw. *Tropics*	47° 00'	3 ways	*Amphiſcians.*
2	Temperate	From the *Tropics* to the *Polar Circles*	43 00 each	1 way	*Heteroſcians,*
2	Frigid	Fr. the *Poles* to the *Polar Circles*	23 30 each	all ways	*Periſcians.*

XXII. From what is above, it will follow, That in the Latitude of 51°. 32'. North; for *Example,*

	° ′		° ′		° ′
The Diſtance from the Equator to the Tropic *Cancer* =	23 30				
From that Tropic to the Zenith is	28 02	*or*	51 32	*leſs*	23 30
From the Zenith to the Artic Circle =	14 58		43 00		28 02
From the Artic Circle, to the Pole =	23 30		90 00		66 30
For Proof, the Sum is from the Pole to the Equator	90 00				
And from the Pole to the Tropic is	66 30	*or*	90 00	*leſs*	23 30
To the Zenith	38 28		90 00		51 32
The Equator to the Zenith	51 32		90 00		38 28
To the Polar Circle	66 30		90 00		23 30

XXIII. The Climates ſhew the Variation of the Length of Days and Nights, and of the Riſing and Setting of the Stars; as the Zones do the Quality of the Air in reſpect to Heat and Cold, and the Diſtinction of the Inhabitants, and their Shadows. A Climate is that Space of Earth contained between the Equator (where the Artificial Day is 12 Hours,) and that Place where the longeſt Day is increaſed half an Hour. So

The firſt Climate extends from the Equator Northward or Southward to where the Day is 12$\frac{1}{2}$ Hours.

The ſecond Climate extends from where the longeſt artificial Day is 12$\frac{1}{2}$ Hours, to where it is 13.

The third Climate extends from where the longeſt Day is 13 Hours, to where it is 13$\frac{1}{2}$, *&c.*

So that according to the Increaſe of Days, there will be twenty-four Climates in each Hemiſphere, counting no farther than the Polar Circles.

XXIV. The notable Points of the Compaſs are eſteemed by theſe ſeveral Profeſſions thus: The Faces of

	Their Right to the	*Left to the*
Prieſts to the Eaſt,	South	North.
Aſtronomers the South,	Weſt	Eaſt.
Geographers the North,	Eaſt	Weſt.
Poets the Weſt,	North	South.

XXV. The Parts of this Terreſtrial Globe, are as the Celeſtial, *i.e.* the Ball, Braſs Meridian, Hour-Circle, Index, and Quadrant of Altitude; *whoſe Uſes follow.*

PROBLEM I.

To find the Latitude of any Place.

THE Latitude is the Diſtance reckoned in the Brazen Meridian from the Equator Northward or Southward; ſo that if you bring the Place, whoſe Latitude you would know, to the Meridian, it will ſhew its Diſtance from the Equator.

So the Latitude of		*Longitude.*
	° ′	° ′
London is	51—32 North.	27—00
Paris	48—45 N.	27—40
Stockholm	59—26 N.	43—39
Copenhagen	56—13 N.	41—00
Criaco	49—56 N.	46—47
Vienna	48—14 N.	47—00
Moſcow	55—25 N.	72—00
Rome	41—50 N,	40—30
Madrid	40—25 N.	23—40
Amſterdam	52—29 N.	37—00
Dublin	53—20 N.	20—20
Edinburgh	56—07 N.	24—00
Jeruſalem	32—00 N,	66—00
Mount *Ararat*	39—40 N.	77—30
Eden(Garden)	32—00 N.	77—00

Note, The Longitude is here reckoned from *St. Michael's*, one of the *Azora's*.

PROB. II.

To find the Longitude of any Place on Earth.

THE Longitude of the Places above are reckoned in the Equator from the firſt Meridian, which paſſeth over the Iſland of *St. Michael*, one of the *Azora* Iſlands. So to find the Longitude of *Jeruſalem*, bring it to the Braſs Meridian, then look in the Equator, and there, under the ſaid Meridian, you have 66, the Degrees of Longitude required.

PROB. III.

To find what Hour it is any Time in any Part of the World, when it is 12 *at* London.

SUPPOSE when it is 12 a-Clock at *London*, I would know what Hour it is at *Jeruſalem*?

Becauſe *Jeruſalem* is Eaſtward from *London*, having brought *London* to the Meridian, and put the Index to 12, turn the Globe toward the Eaſt Part of the Horizon, till *Jeruſalem* be under the Meridian, and then the Hour-Index will cut 2 *h.* 50′. Afternoon.

So likewiſe when it is Noon at *London*,

	h.	'	
It will be at *Barbados*	8	15	Before Noon.
At *Jamaica*	6	50	
At *Cape Horn* in *Terra del Fuego*	7	00	
At *Rome*	1	00	After-N.
At *Gibraltar*	11	45	Morn.
At *Conſtantinople*	2	15	After-N.

PROB. IV.

To find at any Hour, at London, *where it will be Noon, or* 12 *a-Clock, at any Place in the World.*

BRING the Place to the Meridian, and put the Hour-Index to 12; then turn the Globe till *London* come to the Meridian; and then the Index will ſhew the Hour, upon a Dial at *London*, when it will be 12 at the ſaid Place. And thus may all the following Towns be put upon a Dial at the ſeveral Times when it will be 12, or Noon, at the ſeveral Places put down.

In the Morning.

	h.	'
Pekin, the Metropolis of *China*, it will be 12 there, when it is here	4	15
Batavia, in the Iſle of *Java* in *Eaſt India*,	5	00
Middle of the Iſle *Sumatra*	5	30
Middle of the upper End of the Bay of *Bengal*	6	20
Agra, the M. of *India*	6	30
Cape *Comorin* in *Eaſt India*, between *Malabar* and *Cormandel* Coaſts,	6	45
Bombay, in *Eaſt India*, on the Coaſt of *Malabar*,	7	00
Cape *Raſalgate*, in *Arabia Fœlix*, entring into the Gulph of *Ormus*,	8	00
Iſpahan, the M. of *Perſia*,	8	22
Baſſora, where the Caravan comes from *Mecca*,	8	35
Babelmandel Streights, entring into the *Red Sea*,	8	52

Middle

	In the Morning.	
	h.	'
Middle of *Madagaſcar* it will be 12 there, when it is here	8	53
Moſcow, Metropolis of *Ruſſia*,	9	10
Aleppo and *Antioch*	9	20
Jeruſalem	9	30
Conſtantinople	9	45
Warſaw, M. of *Poland*,	10	33
Cape of *Good-Hope*	10	38
Stockholm, M, of *Sweden*,	10	40
Vienna, M. of *Germany*,	10	47
Rome, M. of *Italy*,	10	53
Copenhagen, M. of *Denmark*,	11	22
Baſil and *Turin*,	11	24
Antwerp,	11	38
Amſterdam,	11	40
Paris, the M. of *France*,	11	50
Madrid, the M. of *Spain*	12	12

	In the Morning.	
	h.	'
Dublin, Metropolis of *Ireland*,	12	27
Madera	1	17
St. Mary's, a Weſtern Iſland,	1	48
Cape *Trio* in South *America*	2	47
Cape *Farewel*, in *North America*,	3	15
Surinam, in South *America*,	3	45
Barbados	3	50
Antigua	4	15
Bermuda, near the Coaſt of *Virginia*,	4	25
Boſton, in *New-England*,	4	45
New-York	5	00
Port-Royal, in *Jamaica*,	5	30
Middle of the Streights of *Magellan*	5	30
Sea-Horſe Point	6	30
Mexico, in North *America*,	6	50
Port *Nelſon*, in *Hudſon's-Bay*,	7	20
South End of the Iſle *California*	8	08

Explanation of the foregoing *TABLE* there needs little more than what is above.

It ſhews, for EXAMPLE, That it is 12 a-Clock at *Jeruſalem*, when it is 30′ paſt 9 at *London*, and the Counties North or Southward of *London*.

It ſhews alſo the Difference in Time at any Hour: For it being Noon 2*h*. 30′. at *Jeruſalem* before it is at *London*, it is 3 a-Clock *p. m.* of conſequence at *Jeruſalem*, when half an Hour paſt 12 here: And ſo of any other Places and Times that are in the Morning-Hours. But for thoſe in the Afternoon, as *Barbados*, it is but 12 there, when it is 50′ paſt 3 here; and conſequently at 10 in the Morning here, it is but 10′ paſt 6 at *Barbados*: We being 3 Hours and 50 Minutes before them, as lying ſo much more Eaſterly.

PROB.

PROB. V.

To find the Diſtance of any two Places on Earth.

LAY the Quadrant of Altitude on the two Places, which gives the Degrees, and multiply them by 70, and the Product is *Engliſh* Miles. It being found, by actual Menſuration, by Mr. *Norwood*, that there are upwards of 69 Miles in a Degree.

PROB. VI.

To find the Bearing of any one Place from another.

HAVING rectify'd the Globe as to Latitude, and the Quadrant placed in the Zenith, lay it over the other Place you would know the Bearing of, and then the End will cut the Horizon: Right againſt which, in the outward Edge, you will ſee the Point of Compaſs the latter Place bears from the firſt which is brought to the Zenith.

Take the EXAMPLES of the two laſt *Problems*, of the neareſt Diſtance and Bearing of 47 of the moſt noted Places in the World (as follow) from the opulent and famous City of *London*.

In *EUROPE.*

	Neareſt Diſt. Eng. *Miles.*	*Bearing, or Point of Compaſs, from* London.
Paris, the Metroplis of *France*,	208	near S. by E.
Madrid, the M. of *Spain*,	760	near S.
Vienna, the M. of *Germany*,	860	near E. by S.
Stockholm, the M. of *Sweden*,	980	near N.E. by N.
Copenhagen, the M. of *Denmark*,	700	near E. N. E.
Amſterdam, M. of the *United Provinces*,	210	near E.
Bruſſels, the M. of the 10 *Auſtr.* Provinces,	190	near E.

Berlin,

	Neareſt Diſt. Eng. *Miles.*	*Bearing, or Point of Compaſs, from* London.
Berlin, Metropolis of *Upper Saxony* in *Germany*, ——	560	E by N.
Hanover, in *Lower Saxony* in *Germany*,	420	E.
Ausburgh, M. of the Circle of *Suabia*,	435	near E. S. E.
Cracow, the M. of *Poland*, ——	700	near E.
Moſcow, the M. of *Ruſſia*, ——	1530	E. N. E.
Rome, the M. of *Italy*,	840	S. E.
Conſtantinople, M. of *Turkey*, ——	1640	E. by S.
Baſil, M. of *Switzerland*,	400	S. E.
Turin in *Savoy*, ——	525	near S. E.
Gibraltar, in the *Streights* by the *Mediterranean*,	1250	near S. S. W.
Port Mahon, in the Iſle *Minorca*, ——	710	near S.

	Neareſt Diſt. Eng. *Miles.*	*Bearing, or Point of Compaſs, from* London.
Meſſina, Metropolis of *Sicily,* —	1085	near S. S. E.
Venice, the M. of that Republick, —	630	near S. E. by E.
Belgrade M. of *Servia,* in *Europe Turkey,*	980	E. S. E.
Legborn, a Free-Port in *Italy,* —	700	near S. E. by S.

II. *ASIA.*

Jeruſalem in *Paleſtine*	2390	near E. S. E.
Damaſcus the M. of *Syria,* —	2355	near E. S. E.
Aleppo in *Syria* -	2350	near E. S. E.
Iſpahan the M. of *Perſia*	3200	E. by S.
Pekin, the M. of *China*	5180	N. E.
Tartary, about the Middle	4200	near N. E.
Agra, the M. of *Eaſt-India* —	5290	E. by N.

	Neareſt Diſt. Eng. *Miles.*	*Bearing, or Point of Compaſs, from* London.
Bombay, on the *Malabar* Coaſt ——	5300	near E.
Bengal, on the *Cormandel* Coaſt, ——	5460	E.

III. *AFRICA.*

Alexandria in *Egypt*,—	2310	S. E. by E.
Tetuan, the Metropolis of the Empire of *Fez*,	1330	S. by W.
Cape-Coaſt Caſtle in the Middle of the *British* Factories in *Guiney*, ——	3290	S. by W.
Cape of *Good-Hope*, the moſt South Point of *Africa*, ——	6160	S. by E.
Middle of the Iſle *Madagaſcar*, ——	5810	S. E.
Sancta Helena, ——	4830	near S. by W.

IV. *AMERICA.*

	Neareſt Diſt. Eng. *Miles.*	*Bearing, or Point of Compaſs, from* London.
Barbados, one of the *Caribbee* Iſlands,	4270	near W. by S.
New-England,	3360	W. N. W.
Penſilvania,	3710	near W. by N.
Maryland	3780	near W. N. W.
Virginia,	3920	W. N. W.
Carolina,	4200	near W. N. W.
Jamaica,	4900	near W.
Newfoundland,	2100	W. N. W.
North End of *Baffin's* Bay, the moſt North Part of *America*,	2730	N. by W.
Cape-Horn, the moſt Southerly Part,	8890	S. W. by W.

Theſe are the neareſt Diſtances; but they would be much more, if we compute the Diſtance a Ship runs upon ſeveral Courſes to come at a Port. As for *Example*, to *Bengal* in *Eaſt-India* :

	Miles:	
From *London*, Eaſt about	60,	with W. Wind.
Thence Southward,	20,	with N. Wind.
Thence Weſtward, —	750,	with E. Wind.
Thence near South, to make the Cape of *Good-Hope*, —	6300,	with N. Wind.
And thence near N. E. to *Bengal*,	6930,	with S. W. Wind.
Sum =	14060	to *Bengal* in *Eaſt India*.

◆

SECT. IV.

A DESCRIPTION *and* USE *of* MAPS.

I. A MAP is a Repreſentation of the Earth and Sea, or of ſome Part thereof *in Plano*, or as a Plane Superficies.

II. A *Map of the World* ſhews, in two Circles, the Situation or Poſition of the four Quarters of the World: That Circle towards the Right Hand containing *Europe*, *Aſia*, and *Africa*, with the Iſles thereto belonging; and that toward the Left hath in it *America*, with the Iſlands appertaining to it.

III. *The outermoſt* (or *entire*) *Circle*, is the grand or firſt Meridian, from which the Longitude is reckoned Eaſtward, from 1 to 180

Degrees, in the Equator, as appears in the Right-Hand Circle; and from 181 to 360 incluſive, or to the grand Meridian again; which is evident in the Equator, and in the Left Hand Circle.

IV. In this Map of the World the Circles of the Globe are delineated. The Equator is drawn quite through the Middle of both the ſaid Circles, divided into Degrees as aboveſaid, and through every five of thoſe Degrees there paſſeth curved Lines, or Meridians, which meet in the Poles of the World. And by theſe Degrees in the *Equator*, the *Longitude* of any Place is reckoned, or its Situation with reſpect to Eaſt and Weſt. Which Meridians are number'd in every 10 Degrees of the Equator to 360, as is obſerv'd above.

But the *Latitude* of Places is computed by the Degrees in the grand Meridian, reckon'd from the Equator upward or downward, *i.e.* Northward or Southward, and is diſtinguiſhed by curved Lines, which run (or are ſuppos'd) parallel to the Equator through every five Degrees of the grand Meridian; which Parallels are number'd 10, 20, 30, *&c.* And the Double Lines 23 ½ Degrees above the Equator, is the Tropic of *Cancer*, and ſo much below is the Tropic of *Capricorn*. And the curved Line, divided into Degrees, which paſſes through both Circles, and croſſeth the Middle of the Equator, touching the Tropics, doth repreſent the Ecliptic.

V. There are alſo Maps of Part of the World; as, the four Quarters, *Europe*, *Aſia*, *Africa*, and *America*. Theſe have the Degrees of Latitude on the Eaſt and Weſt Sides, and of Longitude on the North and South, all expreſſed by curved Lines.

VI. In ſome Maps the Longitude is reckon'd from *London* at the Bottom; and from *Teneriff*, or ſome other of the *Canary*, *Madera*, Cape *Verd*, or *Azora* Iſlands, at the Top.

VII. In Maps of Part of the World, there are ſo much only of the Meridians and Parallels expreſſed, as fall within ſuch Portion or Part. And in the Maps of Kingdoms only, the ſaid Meridians and Parallels are expreſſed by ſtreight Lines.

VIII. In all Maps the upper Part is the North, the lower South, the Right-Hand Degrees Eaſt, and the Left Weſt; which are ſometimes thus marked:

North ——— *Borealis*, or *Septentrionalis.*

South ——— *Meridionalis*, or *Auſtralis.*

Eaſt ——— *Orientalis.*

Weſt ——— *Occidentalis.*

Note, As to the Zones, Climates, Denominations of the ſeveral Parts of Land and of Water, and different Situation of Inhabitants with reſpect to Shadows, and *Antieſi*, *Perieſi*, and *Antipodes*, they are fully accounted for in the *Uſe of the Terreſtrial Globe*, foregoing.

The LATITUDE *and* LONGITUDE *of the moſt noted Places in the World, the* Longitude *from the Iſle* Teneriff; *and all* North Latitude, *except what is marked* S.

I. *In* EUROPE.

I. In GREAT BRITAIN, &c.

	North Latitude.		*Long. from* Teneriff.	
	°	'	°	'
LONDON, the Metropolis, ——	51	32	18	36
York, the Chief of that County,	54	00	17	46
Edinburgh, the Chief of *Scotland*, ——	56	07	15	50
Dublin, the Chief of *Ireland*, ——	53	20	12	09
The other Cities in England, *i. e.*				
Bath, in *Somerſetſhire*, ——	51	23	16	14

Briſtol,

	North Latitude.		Long. from Teneriff.	
	°	′	°	′
Briſtol, Part in *Somerſetſhire*,	51	30	16	00
Canterbury, in *Kent*,	51	20	19	46
Carliſle, in *Cumberland*,	54	50	15	56
Cheſter, in *Cheſhire*,	53	17	15	51
Chicheſter, in *Suſſex*,	50	51	17	51
Coventry, in *Warwickſhire*,	52	27	17	14
Durham, M. of that County,	54	47	17	16
Ely, in the County of *Cambridge*,	52	24	18	46
Exeter, in *Devonſhire*,	50	44	15	02
Glouceſter, in that County,	51	56	16	26
Hereford, in that County,	52	08	15	44
Lincoln, in that County,	53	17	18	00
Litchfield, in *Staffordſhire*,	52	44	17	00
Norwich, M. of *Norfolk*,	52	43	19	46
Oxford, M. of that County,	51	47	17	16

Peterborough,

	North Latitude.		*Long. from* Teneriff.	
	°	′	°	′
Peterborough, in *Northamptonſhire*,	52	34	18	16
Rocheſter, in *Kent*,	51	24	19	15
Saliſbury, in *Wiltſhire*,	51	03	16	51
Wells, in *Somerſetſhire*,	51	13	16	14
Wincheſter, in *Hampſhire*,	51	03	17	21
Worceſter, in that County,	52	17	16	21
Cambridge Univerſity,	52	13	18	32

The four *Welſh* Cities are,

St. Aſaph, in *Flintſhire*,	53	23	15	21
Bangor, in *Caernarvonſhire*,	53	21	14	36
St. David's, in *Pembrokeſhire*,	52	02	13	36
Llandaff, in *Glamorganſhire*,	51	32	15	21

In

2. In FRANCE; as,

	North Latitude. °	′	*Long. from Teneriff.* °	′
Paris, the Metropolis of the Iſle of *France*, &c: ——	48	45	21	30
Amiens, M. of *Picardy*, ——	49	54	21	26
Rheims, M. of *Champaigne*, —	49	13	23	18
Rouen, M. of *Normandy*, —	49	26	20	02
Rheimes, M. of *Bretagne*, —	48	03	16	30
Orleans, M. of *Orleanois*, —	47	44	20	42
Dijon, M. of *Burgundy*, —	43	47	24	05
Lyons, M. of *Lyonoiſe*, ——	45	24	24	06
Bourdeaux, M. of *Guienne*, or *Gaſcoigny*, ——	44	50	17	50
Thouloufe, M. of *Languedoc*,	43	29	19	48
Grenoble, M. of *Dauphiné*, —	44	54	25	40
Aix, M. of *Provence*, ——	43	04	24	40
Nancy, M. of *Loraine*, ——	48	40	25	40
Beſançon, M. of *French Compte*,	47	07	25	28

3. In SPAIN; as,

	North Latitude.		*Long. from Teneriff.*	
	°	'	°	'
Madrid, the Metropolis, in *New Castile*,	40	25	13	40
Compostella, the M. of *Galicia*,	43	00	08	16
Oviedo, the M. of *Austuria*,	43	23	11	05
Bilboa, M. of *Biscay*,	43	47	14	22
Pampeluna, M. of *Navarre*,	42	52	16	06
Saragosa, M. of *Aragon*,	41	35	17	00
Barcelona, M. of *Catalonia*,	40	34	20	23
Valentia, M. of the Kingdom of that Name,	39	25	17	15
Murcia, M. of that Kingdom,	38	04	16	34
Burgos, M. of *Old Castile*,	42	25	13	30
Leon, M. of that Kingdom,	42	44	11	48
Placentia, M. of *Estramadura*,	39	48	11	50
Seville, M. of *Andalusia*,	37	30	11	14
Cadiz, in *Ditto*,	36	32	10	42

Granada

	North Latitude.		*Long. from* Teneriff.	
	°	'	°	'
Granada, Metropolis of that Kingdom, ——	37	28	13	55
Majorca, M. of *ditto* Iſle,	39	04	20	33
Citadella, M. of *Minorca*, [*Engliſh*,] ——	40	00	22	30

4. ITALY; as,

Rome, M. of *Italy*, ——	41	50	20	02
Chambery, M. of the Dutchy of *Savoy*, ——	45	04	25	24
Turin, M. of the Principality of *Piedmont*, ——	44	34	27	26
Caſale, M. of *Montferrat*, —	44	40	28	17
Genoa, M. of the State of *Genoa*, ——	43	53	29	00
Milan, M. of that Dutchy,	44	55	29	15
Parma, M. of that Dutchy, —	44	24	30	40
Modena, M. of that Dutchy,	44	14	31	32
Mantua, M. of that Dutchy,	44	52	31	10

Trieſt,

	North Latitude.		Long. from Teneriff.	
	°	′	°	′
Trieſt, in *Iſtria*, ——	45	44	34	55
Venice, Metropolis of that Commonwealth, ——	45	20	33	04
Florence, M. of the Dutchy of *Tuſcany*, ——	43	20	32	10
Leghorn, in *Ditto*, ——	43	52	31	00
Naples, M. of the Kingdom of *Naples*, ——	40	56	36	15
Palermo, M. of *Sicily*, —	37	26	34	50
Cagliari, M. of *Sardinia*,—	38	10	30	24

5. In GERMANY; as,

Vienna (the Metropolis) in *Auſtria*, ——	48	14	37	05
Hanover, in *Lower Saxony*,	52	35	29	36
Berlin, M. of *Brandenburgh*,	52	33	33	52
Dreſden, in *Upper Saxony*, —	51	06	33	50

Magde-

†

	North Latitude.		*Long. from* Teneriff.	
	°	′	°	′
Magdeburg, Metropolis of *Lower Saxony*, ——	52	17	32	00
Munſter, M. of *Weſtphalia*, —	52	00	27	12
Strasburg, M. of the Circle cle of the *Upper Rhine*, —	48	28	27	26
Cologn, M. of the Circle of the *Lower Rhine*, ——	50	55	26	32
Augsburg, M. of *Swabia*, —	48	14	30	57
Nurenburg, M. of *Franconia*,	49	24	31	11
Munich, M. of *Bavaria*, ——	47	58	31	36
Prague, M. of *Bohemia*, ——	49	58	34	33
Baſil, M. of *Switzerland*, —	47	34	27	16
Antwerp, M. of *German Netherlands*, ——	51	16	23	36
Bruſſels, M. of *Brabant*, —	50	54	23	36

6. In the UNITED PROVINCES.

	North Latitude.		*Long. from* Teneriff.	
	°	′	°	′
Amsterdam M. of the Seven *United Provinces*, —	52	29	24	00
Hague, in *Holland*, —	52	8	23	22
Haerlem, in *Holland*, —	52	31	23	36

7. In SWEDEN.

Stockholm, the Metropolis, —	59	26	39	5
Riga, M. of *Livonia*, now under the *Czar*, —	56	54	45	34
Notteburg, M. of *Ingria*, —	59	52	34	00
Abo, M. of *Finland* —	60	23	43	33
Lunden, M. of *Schonen*, —	56	44	33	42
Revel, in *Eastland*, now under the *Czar*, —	59	13	46	32
Narva, M. of *Eastland*, now under the *Czar*, —	59	06	50	25
Tornia, M. of *Lapland* —	66	8	44	06
Christianstat, in *Gotbland*, —	56	35	34	16

	North Latitude.		Long. from Teneriff.	
	°	'	°	'
Magdeburg, Metropolis of *Lower Saxony*, ——	52	17	32	00
Munſter, M. of *Weſtphalia*, —	52	00	27	12
Strasburg, M. of the Circle cle of the *Upper Rhine*, —	48	28	27	26
Cologn, M. of the Circle of the *Lower Rhine*, ——	50	55	26	32
Augsburg, M. of *Swabia*, —	48	14	30	57
Nurenburg, M. of *Franconia*,	49	24	31	11
Munich, M. of *Bavaria*, ——	47	58	31	36
Prague, M. of *Bohemia*, ——	49	58	34	33
Baſil, M. of *Switzerland*, —	47	34	27	16
Antwerp, M. of *German Netherlands*, ——	51	16	23	36
Bruſſels, M. of *Brabant*, —	50	54	23	36

6. In the UNITED PROVINCES.

	North Latitude.		Long. from Teneriff.	
	°	′	°	′
Amſterdam M. of the Seven *United Provinces*, —	52	29	24	00
Hague, in *Holland*, —	52	8	23	22
Haerlem, in *Holland*, —	52	31	23	36

7. In SWEDEN.

	North Latitude.		Long. from Teneriff.	
Stockholm, the Metropolis, —	59	26	39	5
Riga, M. of *Livonia*, now under the *Czar*, —	56	54	45	34
Notteburg, M. of *Ingria*, —	59	52	34	00
Abo, M. of *Finland* —	60	23	43	33
Lunden, M. of *Schonen*, —	56	44	33	22
Revel, in *Eaſtland*, now under the *Czar*, —	59	13	46	32
Narva, M. of *Eaſtland*, now under the *Czar*, —	59	06	50	25
Tornia, M. of *Lapland* —	66	8	44	06
Chriſtianſtat, in *Gothland*, —	56	35	34	16

8. IN DENMARK.

	North Latitude.		*Long. from* Teneriff.	
	°	′	°	′
Copenhagen, the Metropolis —	56	13	32	30
Bergen, M. of *Norway*, —	61	00	24	15
Hamburg, M. of *Holſtein*, —	53	57	29	20
Sleſwick, M. of *South Jutland*,	55	57	29	24
Wyburg, M. of *North Jutland*, — —	56	47	28	52

9. IN RUSSIA OR MUSCOVY.

Moſcow, the Metropolis —	55	25	63	00
Archangel, M. of *Dwina* —	64	30	65	10
Novogrod, M. of *Novogrod Weliki*, — —	58	10	55	18
Aſtracan, M. of that Kingdom, — — —	47	00	72	30
Petersburg, at the upper End of the Gulf of *Finland* —	60	30	50	30

10. In

10. In POLAND.

	North Latitude.		*Long. from* Teneriff.	
	°	'	°	'
Cracow, the Metropolis of *Poland*, ———	49	56	40	47
Warſaw, M. of *Maſſovia*, —	52	7	42	5
Dantzick, M. of *Pruſſia*, —	54	13	40	42
Mittau, M. of *Courland*, —	57	00	44	00
Wilna, M. of *Lithuania*, —	54	31	47	14
Lemburg, M. of *Ruſſia Rubra*,	49	36	45	00
Kaminieck, M. of *Podolia*, —	48	50	47	46
Breſte, M. of *Poleſia*, ——	51	55	45	8

11. In TURKEY in *Europe*; as,

Conſtantinople, the Metropolis,	43	00	54	20
Buda, the M. of *Lower-Hungary*, now under the Emperor, ——	42	17	41	44
Belgrade, M. of *Servia* now under the Emperor, —	45	20	42	34

	North Latitude. °	′	*Long. from* Teneriff. °	′
Temiſwar, M. of that Government, und. Emp.	46	6	43	24
Adrianople, in *Romania*, —	43	18	51	00
Zaza, M. of *Dalmatia*, —	44	34	37	20
Poſega, M. of *Sclavonia*, —	45	46	39	42
Hermanſtad, M. of *Tranſilvania*, under the Emp.	46	46	[illegible]5	48
Salonica, or *Theſſalonica*, M. of *Macedonia*, —	41	37	47	00
Miſiſtbra, M. of the *Morea*,	35	25	47	32
Aſoph, M. of *Crim Tartary*, by ſome in *Aſia*, —	46	00	61	00

II. *ASIA.*

	°	′	°	′
Jeruſalem, the Metropolis of *Paleſtine*, ——	32	44	69	00
Damaſcus, M. of *Syria*, —	33	00	69	00

	North Latitude.		*Long. from* Teneriff.	
	°	′	°	′
Aleppo, in *Syria*, —	31	45	58	20
Tripoli, in *Syria*, —	34	20	63	39
Gaza, in *Paleſtine*, near the *Mediterranean*, —	31	45	65	26
Smyrna, in *Natolia* or *Leſſer Aſia*, —	35	45	55	45
Epheſus, in *Leſſer Aſia*, —	39	00	55	45
Burſa, in D°. near the *Propontis*, —	41	49	57	35
Babylon, M. of *Aſſyria*, —	35	00	79	00
Balſora, in *Arabia Deſerta*,	31	00	66	00
Famagoſta, in *Cyprus*, —	34	00	58	00
Medina, in *Arabia Deſerta*,	26	00	70	10
Mecca, in *Arabia Fœlix*, —	23	00	61	00
Iſpahan, M. of *Perſia*, —	32	26	86	40
Teflis, the M. of *Georgia*, —	43	5	83	00
Selenginskoi, about the Middle of *Tartary*, —	57	00	107	30

	North Latitude.		*Long. from* Teneriff.	
	°	′	°	′
Pekin, the M. of *China*, —	40	00	127	00
Meaco, the M. of *Japan* —	35	00	149	00
Agra, the M. of the *Mogul's* Empire, —	25	30	89	30
Bombay, on the *Malabar* Coaſt, *Eaſt India*, —	19	00	86	00
Goa, on D° Coaſt —	15	00	83	00
Fort St. George, on the *Coromandel* Coaſt, *India*, —	13	20	94	00
Fort St. David's, on Ditto Coaſt, —	12	30	93	00
Mindanao, one of the *Philippine* Iſlands, —	7	00	135	30
Manila, M. of another of D°, *viz.* of *Luconia*, —	14	30	133	00
Bencouli, in the Iſland *Sumatra*,	2	30	112	00

III. *AFRI*

III. *AFRICA.*

	North Latitude.		*Long. from* Teneriff.	
	°	'	°	'
Madagaſcar Iſle, the Middle,	21	00 S.	59	00
Cape of *Good Hope*, ——	34	30 S.	30	00
Santa Helena, in the *Atlantic* Ocean ——	15	30 S.	07	30
Cape Coaſt Caſtle, the Middle of the *Engliſh* Factories,	5	00	13	00
Tetuan, the M. of the Empire of *Fez*, ——	34	20	8	00
Tunis, on the Coaſt of *Barbary*, ——	32	10	34	53
Grand Cairo (or *Memphis*) M. of *Egypt*, ——	36	4	38	48
Alexandria, by the *Nyle*, on the *Mediterranean* ——	31	25	58	20

	North Latitude.		*Long. from* Teneriff.	
	°	'	°	'
Ceuta, upon the Streights of *Gibraltar*, ——	35	50	08	10

IV. *AMERICA.*

1. *In* NORTH AMERICA.

	North Latitude.		*Long. from* Teneriff.	
	°	'	°	'
Quebec, the Metropolis of *Canada* or *New France*,	47	12	304	30
Boston, M. of *New England*, ——	44	00	309	00
Elizabeth Town, M. of *Jersey*, ——	42	00	306	30
New York, M. of *New York*, ——	42	30	306	00
Philadelphia, M. of *Pensilvania*, ——	41	00	306	30
Oxford, Metropolis of *Maryland*, —— ——	38	30	305	30

James

	North Latitude.	*Long. from* Teneriff.
James Town, the M. of *Virginia*,	36 30	305 30
Charles Town, M. of *Carolina*,	33 00	296 00
St. Austin's, the M. of *Florida*,	29 00	294 00
St. Fé, the Metr. of *New Mexico*,	36 00	263 00
Mexico, the Metr. of *New Spain*,	20 00	271 00
Califurnia, the Middle of it,	33 30	243 00

2. In SOUTH AMERICA.

Panama, in the *South-Sea*,	08 30	294 30
Darien, or *Calidonia*, in *Terra Firma*,	09 00	295 30
Lima, the Metropolis of *Peru*,	13 30 S.	298 00

St.

	North Latitude. ° '	Long. from Teneriff. ° '
St. Salvador, the M. of *Brazil*,	12 30 S.	338 00
Villa Rica, M. of *Paraguay*,	22 30 S.	318 00
St. Jago, the M. of *Chili*,	34 00 S.	300 50
Carthagena, near the *Iſthmus* of *Darien*,	10 00	300 00
Porto Bello, in *Terra Firma*,	10 00	292 00

3. ISLANDS.

Newfoundland, Port *St. John's*,	47 30	323 00
Bermudas, or the *Summer Iſlands*, *St. George*,	33 15	311 00
Havana, M. of *Cuba*,	23 00	292 00
Port Royal, M. of *Jamaica*,	18 20	298 30
St. Domingo, the M. of *Hiſpaniola*,	18 15	303 00

Bar-

	North Latitude.	*Long. from* Teneriff.
	° '	° '
Barbados, the Middle, M. of the *Caribbees*, —	13 45	313 40
Antigua, alſo one of the *Engliſh Caribbees*, —	15 40	315 40

And *Note*, That

Baffin's Bay, the N. End, and moſt Northerly Part of *America*, is	78 00	318 00
Cape Horn, the moſt Southerly Part of *America*, is —	58 00 S.	294 00
Cape Caglia, in the *Morea*, the moſt Southerly Part of *Europe*, is	36 49	39 30
North Cape, the moſt Northerly Part of *Europe*, is —	71 50	42 00
Cape Comorin, in *Eaſt India*, the moſt Southerly Part of *Aſia's* Continent, is —	08 00	93 00

Holy

	North Latitude.	Long. from Teneriff.
	° ′	° ′
Holy Cape, in *Tartary*, the moſt Northerly Part of *Aſia*, is	73 30	145 00
Streight of *Gibraltar*, the moſt North Part of *Africa*, is ——	36 10	11 00
Cape of Good-Hope, the moſt Southerly Part of *Africa*, is ——	34 30 S.	30 30

The USE *of the laſt* Tables *of* LATITUDE.

1. IN *ſtraight-lin'd Maps*, as thoſe of *England*, the Latitude and Longitude being found, as in the Beginning of the *Table* for the Cities, the Latitude of Places of leſſer Note may be found, if they lie near or under the ſame Meridian with thoſe Cities. Thus the Latitude of *Cheſter* being 53° 17′ the Latitude of *Wigan* is found by adding its Diſtance in Miles from *Cheſter*, = 22. which makes *Wigan* in the Latitude of 53° 39′: And *Preſton* being 12 Miles farther, that being added to 53. 39, gives 53. 51, its Latitude; for every Mile, adding a Minute: which is near enough the Truth, and will make no ſenſible Error in Dialling, *&c.*

2. In theſe Kind of Maps (the Latitude and Longitude being given as by the *Table*) the true Situation of any Place may be found: For, lay a Ruler to the Degrees of Latitude on the Eaſt and Weſt Side of the Map; and then about the Place of the Longitude draw a Line with a Black-lead Pencil two or three Inches; then lay your Ruler to the Degrees of

Longitude at the Top and Bottom of your Map; and where it croſſeth the aforeſaid ſhort Line, there is the Place where the Town or City given, is or ſhould be placed in the Map.

3. Or to find the Latitude of any Place in theſe Kind of Maps, ſet one Foot of a Pair of Compaſſes in the (o) which is the true Place of the Town, and extend the other to the next Parallel below; then apply that Diſtance to the Eaſt or Weſt Sides of the Map, and you have the Degrees and Minutes to be added to the Number the ſaid Parallel is marked with, to give the Latitude.

4. And for the *Longitude*, take the neareſt Diſtance from the (o) Town or City to the next Meridian Weſtward, and apply that to Top or Bottom of the Map, and that will ſhew what is to be added to the Figure with which the ſaid Meridian is marked, to give the Longitude.

5. But where the Longitude is reckoned from two Places (the one marked by Degrees at the Top, the other at the Bottom, as is obſerved under the 6th Article, near the Beginning of this *Section*) you muſt apply the ſaid Diſtance between your Compaſſes to the Top or Bottom, according to the Place you are

minded to know the Longitude from. And for thoſe Maps whoſe Meridians and Parallels are curved Lines, the Method is the ſame, making Allowance for the Curvature: But mind to take the Diſtance of Places, and meaſure them from the next Meridian Eaſtward or Weſtward, according to their Situation at the Bottom of the Map, if the firſt Meridian is that of *London*: For there is 0 for the Meridian of *London*, and the other Meridians are number'd 1, 2, 3, *&c.* Eaſtward and Weſtward; Lines being drawn through every five Degrees.

Thus, for *Example*, I would know the Latitude of Cape *St. Vincent*, and its Longitude from *London*: I find the Latitude (by a Map of *Europe*, as Mr. *Moll's*) to be 36 Degrees, 50 Min. and the Longitude Weſt is 10 Degrees from *London* (as by the Bottom of the Map) or the Longitude is 9 Degrees Eaſtward from *Ferro*, one of the *Canary* Iſlands.

6. Having thus far ſhewed the Deſcription of the ſeveral ſorts of Maps, and alſo to find the Latitude and Longitude by them, I proceed to ſhew how

To find the Diſtance between Places by right-lin'd MAPS.

Rule. This is very eaſily done: For if you take with a Pair of Compaſſes the Diſtance between the 2 Places, and apply that to one Side of your Map, it will give the Number of Degrees and Minutes; which Degrees, multiplied by 70, exhibit the Number of Miles. And if there be any Minutes, they are ſo many $\frac{7}{6}$; therefore they muſt be multiplied by 7, and divided by 6.

7. Now the Reaſon why we multiply the Degrees by 70, to give the Miles in any Number of Degrees, is, becauſe Mr. *Norwood*, by actual Meaſuring, found, that a Degree upon the Surface of the Earth did contain 69$\frac{7}{8}$ *Engliſh* Statute Miles, of 1760 Yards each. So a Degree in round Numbers, without any conſiderable Error, may be called 70 Miles.

Note alſo, The Reaſon why the Minutes, when there are any, are to be multiplied by 7, and divided by 6, is, becauſe there are 60 Minutes in a Degree, equal to 70 Miles. Therefore, As 60 Minutes is to 70 Miles; ſo is any Minute to its Miles.

As ſuppoſe I would know the Miles in 30 Minutes, 'tis thus:

60 : 70 :: 30 : 35

Or, omitting the Cyphers in each of the two firſt,

6 : 7 :: 30 : 35

Which is half of 70, as 30 is of 60.

And here I think it may be proper to give the Proportion of *Engliſh* to other Country Miles and Degrees.

Miles or Leagues of ſeveral Countries.	*Of which are in 1 Degree near.*	Or Engliſh *Miles in 1 of theirs near.*
The *Engliſh* Statute Mile of 1760 Yards, ——	— 70	1
The *Italian* Mile, ——	— 60	$1\frac{1}{5}$
The *German* Mile, ——	15	$4\frac{78}{100}$
The *Spaniſh* League, ——	22	$3\frac{11}{16}$
The *Swediſh* League, ——	15	$4\frac{39}{53}$
The *Hungarian* League, ——	$12\frac{1}{2}$	$5\frac{36}{53}$
The *Scotiſh* Mile, ——	56	$1\frac{4}{10}$

8. But farther, as to *the Diſtance of Places* in Maps; there are Scales of *Engliſh* and other Country Miles and Leagues, by which 'tis very eaſy to find Diſtances with Accuracy. Setting one Foot of a Pair of Compaſſes in the one Place, and extending the other Foot to the other Place, and applying that Diſtance to the Scale, will give the Miles or Leagues reſpectively.

9. In Caſe where Degrees of Longitude are leſs than the Degrees of Latitude, as they are toward the Poles (eſpecially in all Maps where the Meridians have any Curvature,) take the

Diſtance of the two Places between your Compaſſes, and apply it to the Right or Left Sides of your Map, as near againſt the Middle of the Diſtance between the two Places as you can eſtimate; which giving the Degrees, multiply them by 70, and you have the Miles.

EXAMPLE.

In Mr. *Moll's* Map of *Europe*, I find the Diſtance between *Vienna* and *Madrid* to be 13° 15′ by the Degrees on the Side of the Map, from 40 upward; which is, by the *Rule* under the 6th Head laſt above, 927 Miles.

And farther, as to Circular Lined Maps.

10. If two Places have the ſame Longitude, and are of the ſame Side of the Equator, the Difference of their Latitudes is their Diſtance in Degrees, &c. as by the 6th Head. So from *Arles* in *Provence*, to *Utrecht* in *Holland*, is 7° 28, or 522 Miles.

11. If two Places lie under the Equator, the Degrees there contained between them, is their Diſtance, &c. as by the 6th Head. So from the Iſland *St. Thomas* in the *Ethiopian* Sea, Eaſtward to the Iſle *Baſſa de Ambra* in the *Indian* Ocean, (as may be ſeen by a Map of *Africa*)

is 40° 20′ or 2823 Miles; as by the 6th Head.

12. If two Places given have the ſame Longitude, but the one is in South, the other in North Latitude; in this Caſe the Sum of the Latitudes is the Diſtance in Degrees, *&c.* So the Diſtance from *St. Helena* in 15° 30′ of South Latitude to the Middle of the Streights of *Gibraltar* in the Latitude of 35.58 North; here the Sum of the Latitudes is = 51.28; which, by the 6th *Rule* laſt above, is 3602 Miles for the neareſt Diſtance.

If Places differ both in Longitude and Latitude, their Diſtance may be found near enough the Truth, by *Rule* the 9th laſt above. Or by *Prob.* V. of *Sect.* III. 'tis done eaſily and accurately.

SECT. V.

A DESCRIPTION *and* USE *of the* SECTOR.

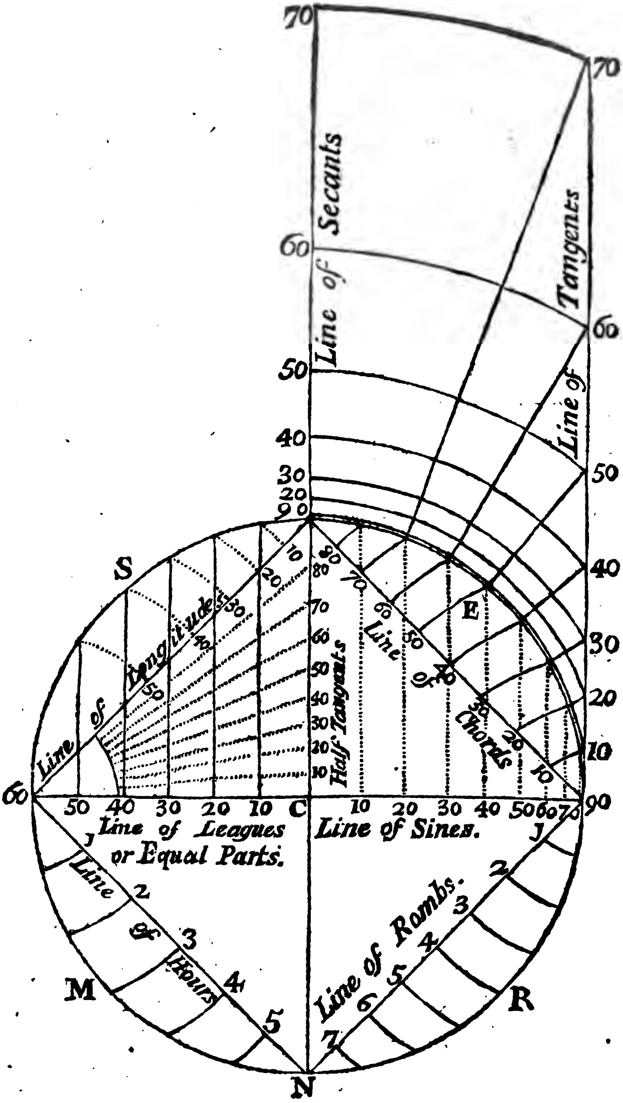
I. THE Sector is a ſmall Inſtrument about a Foot in Length, with a Joint in the Middle, which gives it two Parts, or Legs, each ſix Inches in Length; and their Breadth is ſix Tenths of an Inch, and Thickneſs about an Eighth of an Inch.

II. Its Uſe is to ſolve Queſtions in Trigonometry, and many others both Arithmetical and Geometrical.

III. The Lines on the Sector are,

1. *Chords*,
2. *Tangents*,
3. *Secants*,
4. *Half Tangents*,
5. *Sines*,
6. *Leagues*, equal Parts, or the Line of Lines.
7. The Line of *Longitudes*,
8. The Line of *Hours*, and
9. The Line of *Rhombs*.

All which proceed, or have their Foundation, from the Circle; as appears by the following *Scheme*.


Line of Secants
Line of Tangents
70
60
50
40
30
20
90
S
Line of Longitude
10
20
30
40
50
80
70
60
50
40
30
20
10
Half Tangents
Line of Chords
E
60
C
50 40 30 20 10
Line of Leagues
or Equal Parts.
10 20 30 40 50 60 70 90
Line of Sines.
Line of Hours
1 2 3 4 5
M
Line of Rombs.
1 2 3 4 5 6 7
R
N

In

In the SCHEME.	*On the* SECTOR.
1. THE *Line of Chords*, is the Quarter of the Circle marked (E) divided into 90 equal Parts; and with one Foot of the Compaſſes in the Center at 90, they are transfer'd to the ſtreight Line 90,90, and number'd 10, 20, &c. to 90.	THE Line of Chords is marked C, and there are two extending from the Center to the ſquare End, numbered 10, 20, &c. to 60.
2. *The Line of Tangents*, is the perpendicular Line, numbered from the Diameter upwards (next the Right Hand) from 10 to 70, made by laying a Rule from the Center to the Degrees for the Chords in the Arch.	There are 4 Lines, marked *T* and *Tan.* 2 on one Leg and 2 on the other, the Lines *T* extend from the Center to the ſquare End, numbered 1 to 45, and the 2 *Tan.* Lines are from 45 to 75, &c.
3. *The Line of Secants*, is parallel to the Line of Tangents, extending from the perpendicular Diameter,	The Secants are 2 ſhort Lines under the Lines of Chords, marked Sec. 1. on each

ter, and numbered upward, 10 to 70, and is made, by ſetting one Foot in the Center of the Circle, and with the other, transferring the Diviſions on the Tangent Line to the Line of Secants.

each Leg, on my Sector.

4. *The Line of Half Tangents*, is upon the Upper perpendicular Semi-Diameter, numbered upwards 10, 20, *&c.* to 90; and is made by laying a Ruler to the Angle 60 toward the Left Hand, and to the Degrees in the Chords from whence the Arch are made.

But on the Sector, there is no Line of Half Tangents, but the Scheme ſhews how they are generated.

5. *The Line of Sines* is the Right Hand Semi-Diameter, numbered 10, 20, *&c.* to 90, from the Center, and is made by drawing perpendicular and parallel Lines, from the Degrees in the Arch of the

There are 2 Lines of Sines, each proceeding from the Center; one on the Upper, the other on the lower Leg, numbered from 1 to 90 each.

This

the uppermoſt right Hand Quadrant to the Semi-Diameter (C 90).

6. *The Line of Leagues*, is the Semi-Diameter next the left Hand, numbered 10, 20, *&c.* to 60, from *C* the Center; and this is alſo a Line of equal Parts, made by dividing it, 1ſt into 2, and thoſe Parts each into 3; and each of thoſe are ſuppoſed to be divided into 10.

This Line upon the Sector, is commonly called the *Line of Lines*: There are on each Leg one marked L, and is numbered from the Center, 1, 2, *&c.* to 10; but is really from 1 to 200.

7. *The Line of Longitudes*, is on the upper Chord Line next the Left Hand, and is numbered downward, 10, 20, *&c.* to 60; and is made by drawing Lines from the equal Parts, parallel to the upper Semi-Diameter, till they cut the Arch (60, 5, 90,) and then ſetting one Foot of the Compaſſes in 60, you

This Line is not on the Sector; but you have the two *Lines of Polygons*, next the parting of the two Legs when the Sector is ſhut, number'd from 4 toward the Left Hand, to 12.

This

you tranſfer the Diviſions in the Arch to the Chord Line.

8. *The Line of Hours*, is made by dividing the Arch (60, M N) into 6 equal Parts: and with one Foot of the Compaſſes in 60, tranſfer them to the Chord Line (60, 12,)

This Line of Hours is the uppermoſt (on my Sector next the joint End) and is number'd 1 to 6; and under that is a Line of Chords of a ſmall Radius.

9. *The Line of Rhombs*, is the Arch (N, R, 90) divided into 8 equal Parts, and with the Compaſs's Foot on 90, they are transfer'd to the Chord Line (N 90)

There are alſo 2 Lines on the S and T Side, at the Bottom next the Joint; one is of Latitudes, and the other of the Inclination of Meridian, on my Sector.

The USE *of the* SECTOR.

THIS Inſtrument is commonly uſed partly opened, according as the Caſe requireth. And whereas the Compaſſes are ſometimes extended on one and the ſame Line from the Center End towards the Square End; Secondly, And ſometimes athwart, from Diviſions on one Leg to thoſe on the other; I ſhall call

The Firſt, *The Lineal (Extent of the Compaſſes, or) Diſtance.*

The Second, *The Diagonal Diſtance (or Extent) for Shortneſs.*

PROB. I.

Divide a Circle into 4, 5, 6, &c. to 12 equal Parts; or to make any regular Polygon.

RULE.

TAKE the Radius, or Semidiameter, of the Circle between your Compaſſes, and apply it on the Lines of Polygons, by a diagonal Extent from 6 on one Leg to 6 on the other: Then keeping the Legs at that Diſtance,

The Diagonal Extent from —	5 to 5	will divide the Circle into —	5 equal Parts.
	6 to 6		6
	7 to 7		7
	8 to 8		8 *&c.*

And ſo by drawing Lines, you have the Pentagon, Hexagon, Heptagon, Octagon, *&c.*

PROB. II.

To make a regular Polygon whoſe Side ſhall be any right Line given.

RULE.

SUPPOSE you would make an Octagon: Take the Line given between your Compaſſes, and opening the Sector, apply that Diſtance, on the Line of Polygons, diagonally from 8 on one Leg, to 8 on the other; then, keeping the Legs and that Diſtance, take the diagonal Extent from 6 to 6 in the Line of Polygons, and with that Radius deſcribing a Circle, the ſaid diagonal Diſtance between 8 and 8 will divide the Circle into 8 equal Parts; ſo that drawing Lines, you have the Octagon required. And the like of any other Polygon.

PROB. III.

To ſet the Sector ſo, that the two Lines of equal Parts may make a right Angle at the Center.

RULE.

IN a right-angled Triangle, if the Perpendicular be 3, the Baſe 4, the Hypothenuſe will be 5; therefore upon the Line of Lines take from the Center the lineal Diſtance to 5; then open the Sector ſo, that that Diſtance will extend from 3 on one of the Line of Lines, to 4 on the other; and then your two Lines of Lines make a right Angle. But ſee after the next *Problem.*

PROB. IV.

To find a third Proportional to two given Lines; as ſuppoſe 40 *and* 60.

RULE.

TAKE the lineal Diſtance of 60, and ſet on the diagonal Diſtance of 40; then the diagonal Diſtance of 60 will give the lineal Diſtance of 90.

And in like manner,

In 15 and 30, the 3d Proportional is ſound = 60.

20 and 30,——————————— = 45.

And ſo on.

But *note* as to *Prob.* III. the ſame may be done thus: Take 60 of the Line of Chords, and make that a lineal Diſtance of the Line of Lines, it will be 34.5; then take 90 out of the Line of Chords, and ſet it a diagonal Diſtance on the Line of Lines from 34.5, to 34.5, and the two Lines of Lines will make a right Angle.

PROB. V.

Two Lines given to find a geometrical mean Proportional between them.

RULE.

THIS is not done by the Sector, without much Trouble; and therefore the Arithmetical Rule of multiplying the Numbers together, and contracting the Square Root for the Anſwer, is much preferable.

So the Mean between 20 and 80 is = 40;
between 15 and 60 is = 30;

And ſo on.

PROB. VI.

To find a fourth Line in Proportion Geometrical to three given.

RULE.

THE Lines given being 20 : 40 :: 30 : 60 : Take the lineal Diſtance of 40, and ſet it a diagonal Diſtance between 20 and 20; then take the diagonal Diſtance (upon the laſt Angle) from 30 to 30, and it will give you a lineal Diſtance of 60, all on the Line of Lines.

Or this may be done, as under the firſt *Rule*, by the Sector, in the fifth *Caſe* of oblique-angled Triangles following.

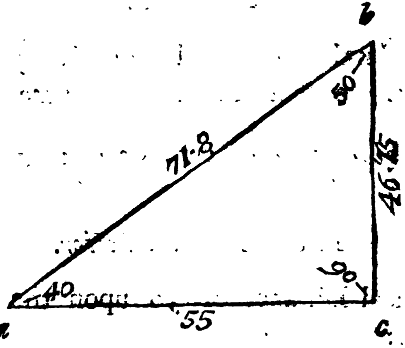
II. QUESTIONS *in* Trigonometry, *done by the* SECTOR.

[*Note, That the Angle* a c b *is the Angle* c, a b c *the Angle* b, *and* b a c *is the Anat* a.]

CASE I.

The Angles *a b c* and *b a c*, and the Baſe *a c* given, to find the Perpendicular *b c*.

As, *c b a* : *a c* :: *b a c* : *b c*.



RULE *by the* SECTOR.

The lineal Diſtance of 90 upon the Line of Sines:

Being ſet to a diagonal Diſtance on the Lines of Lines of 55:

So the Lineal Diſtance of 40 upon the Line of Sines;

Gives the diagonal Diſtance of 46.15 on the Line of Lines (the ſame Angle of the Sector continued.):

CASE II.

The Angles *abc* and *bac* given, and the Side *ac*, to find the Hypothenuſe *ab*; as,

cba : *ac* : : *acb* : *ab*.

RULE *by the Sector.*

The lineal Diſtance of 50 upon the Line of Sines:

Being ſet to the diagonal Diſtance of 55 on the Line of Lines: :

So the lineal Diſtance of 90 on the Line of Sines:

Will (upon the ſame Angle) give the diagonal Diſtance of 71.8 upon the Lines of Lines.

CASE III.

The Angles *abc* and *bac*; and the Hypothenuſe *ab* given: To find the Baſe *ac*: As,

acb : *ab* : : *abc* : *ac*.

RULE *by the Sector.*

The lineal Diſtance of 90 upon the Line of Sines:

Being ſet to the diagonal Diſtance of 71.8 on the Lines of Lines : :

So the lineal Diſtance of 50 on the Line of Sines:

Will give (upon the ſame Angle) the diagonal Diſtance of 55 upon the Lines of Lines.

CASE IV.

The Baſe *ac*, and the Perpendicular be given, to find the Angle *bac*: As,

ac : *acb* :: *bc* : *tang. bac.*

RULE *by the Sector.*

The lineal Diſtance of 55 upon the Line of Lines:

Being ſet to a diagonal Diſtance of 90 upon the Line of Sines: :

So the lineal Diſtance of 46.15 upon the Line of Lines:

Will (upon the ſame Angle of the Sector) give the diagonal Diſtance of 40 on the Tangents.

CASE V.

The Baſe *ac* and Perpendicular *bc* given, to find the Hypothenuſe *ab*;

1ſt. as, *ac* : *acb* :: *bc* *Tang.* *bac*
2dly. as, *bac* : *bc* :: *acb* : *ab*= the Anſ.

RULE *by the Sector.*

This is done by two Operations; 1ſt, as in the 4th Caſe to find the Angle *bac*: Then, ſecondly, lineal Diſtance of 40 on the Sines, ſet to a diagonal Diſtance of 46.15, on the Line of Sines :: The lineal Diſtance of 90 on the Lines, will (the Sector continued in the ſame Angle) give the diagonal Diſtance of 71.8. = the Anſwer.

CASE VI.

The Hypothenuſe *ab*, and Baſe *ac* given, to find the Angle *abc*; as,

ab : *acb* :: *ac* : *abc*.

RULE *by the Sector.*

As the lineal Diſtance of 71.8 upon the Line of Lines:

Is to the diagonal Diſtance of 90 upon the Line of Sines::

So is the lineal Diſtance of 55 upon the Line of Lines:

To the diagonal Diſtance of 50 on the Line of Sines. = the Anſwer.

CASE VII.

The Hypothenuſe *ab*, and Baſe *ac* given, to find the Perpendicular *bc*;

1ſt. As, *ab* : *acb* :: *ac* : *abc*;

As Caſe 6, and the Complement of *acb*, is *bac* = 40.

2dly. As, *abc* : *ac* :: *bac* : *bc*.

RULE *by the Sector.*

Here being two Operations, the firſt is performed as under Caſe the Sixth: And for the ſecond Operation;

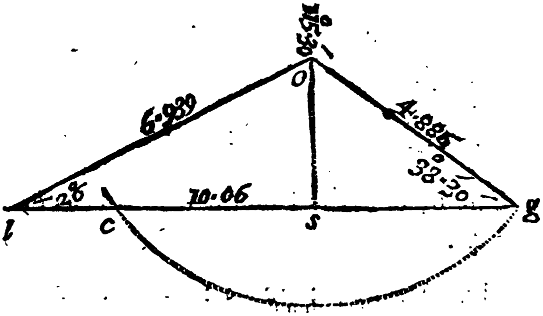
As the lineal Diſtance of 50 upon the Line of Sines:

Is to the diagonal Diſtance of 55 upon the Line of Lines::

So is the lineal Diſtance of 40 on the Line of Sines:

To the diagonal Diſtance of 46.15 on the Line of Lines. = the Anſwer.

Here follow five Caſes of oblique-angled plain Triangles.



CASE I.

The Angles olg and ogl, and Side ol given; To find the Side og; as,

$$ogl : ol :: olg : og.$$

RULE *by the Sector.*

As the lineal Diſtance 38.30 on the Line of Sines;

Is to the diagonal Diſtance of 6.9 on the Line of Lines::

So is the lineal Diſtance of 26 on the Line of Sines:

To the diagonal Diſtance of 4.9 on the Line of Lines.

CASE II.

The Sides *ol* and *og*, and the Angle *ogl* given, to find the Angle *olg*; as,

$$ol : ogl :: og : olg.$$

RULE *by the Sector.*

As the lineal Diſtance of 6.9 on the Line of Lines;

Is to the diagonal Diſtance of 38.30 on the Line of Sines::

So is the lineal Diſtance of 4.9 on the Line of Lines:

To the diagonal Diſtance of 26 on the Line of Sines. = the Anſwer.

CASE III.

The Sides lo and lg, and the Angle olg given, to find the Angle o or g; As, $lo + lg : lg - lo :: tang. \frac{log + lgo}{2}\ tang. \frac{log - lgo}{2}$;

That is, as the Sum of the two Sides lo more lg:

Is to the Difference of the two Sides lg leſs lo ::

So is the Tangent of half the Sum of the oppoſite Angles log and lgo:

To the Tangent of half their Difference log leſs lgo:

And the half Sum and half Difference added, give the Angle log:

But the half Sum leſs, the half Difference gives the Angle lgo.

RULE *by the Sector.*

I ſhall leave to the Reader to find out, after ſo many Examples of the manner of Operation: And ſhall only tell the Stranger to Trigonometry, that he may work any of the Caſes above, by the Tables of Sines, Tangents and Logarithms, taking the Sines of the Angles, and the Logarithms of the Sides, adding the ſecond and third together, and ſubtracting the firſt.

CASE IV.

The Sides *lg* and *go*, and the Angle *olg* given, to find the Angle *log*; as,

go : *olg* :: *lg* : *log*

Its Complement to 180°.

RULE *by the Sector.*

As the lineal Diſtance of 4.886, or 4.9, on the Line of Lines :

Is to the diagonal Diſtance of 26 on the Line of Sines ::

So is the lineal Diſtance of 10.06, or 10, on the Line of Lines :

To the diagonal Diſtance of 64° 30′ on the Line of Sines. = the Anſwer.

But in theſe Caſes, obſerve, That the Angle now found *(log)* being very plainly an obtuſe Angle, or above 90 Degrees; therefore the 64.30 muſt be only the Complement to 180 Degrees: So that 180 leſs 64.30, reſts 115° 30′ the true Quantity of the Angle *log* ſought. And Note, when the obtuſe Angle is given, you muſt work with its Complement.

CASE V.

The three Sides of an oblique-angled plain Triangle given, to find an Angle.

As the Side *lg* is to the Sum of the Sides *ol* and *og* = 11.82 : :

So is the Difference of thoſe two Sides = 2.053, to the Line *lc* = 2.413.

This may be done either by natural Numbers, or Logarithms, or *by the Sector*, thus:

As the lineal Diſtance of 10 on the Line of Lines :

Is to the diagonal Diſtance of 11.8 on that Line of Lines : :

So is the lineal Diſtance of the Difference = 2.053 on the Lines :

To the diagonal Diſtance of 2.413 on the ſame Line of Lines.

Secondly, Then the Side *lg* = 10.06, leſs 2.413 is = 7.647 = the Line *gc*; which divided by 2, gives the Side of the right-angled Triangle *gs* = 3.823.

Thirdly,

As the lineal Diſtance of the Side of the Triangle $og = 4.886$ on the Line of Lines:

Is to the right Angle osg on the Line of Sines (taken diagonally) : :

So is the lineal Diſtance of $sg = 3.823$ on the Line of Lines :

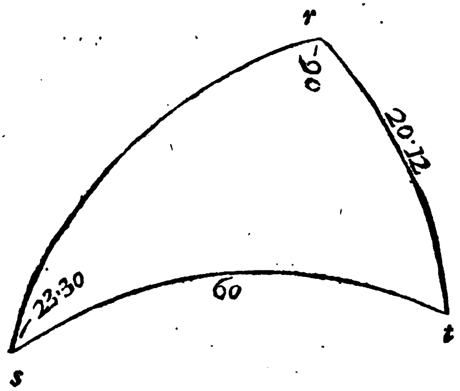
To the Angle (or diagonal Diſtance) $sog =$ 51° 30′ on the Line of Sines.

Fourthly, 90 leſs 51.30 gives the Angle ogs = 38° 30′, the Anſwer.

And thus, though I have not profeſſedly treated on Trigonometry ; yet the *Rules* above ſhew how to ſolve any of the Caſes in right-lined plain Triangles, and eſpecially by the Sector. I ſhall ſhew next how to ſolve a Caſe in ſpherical Triangles, and conclude the Uſe of this little portable Inſtrument.

Note, That in right-lined Triangles the three Angles are equal to two Right, or 180 Degrees ; but in ſpherical, the three Angles are more than 180 Degrees.

The Angles $srt = 90°\ 00'$, and $rst = 23°\ 30'$, and Hypothenuſe 60° ; to find *rt*.



As, *srt* : *st* :: *rst* : *rt*.

RULE *by the Sector.*

Take the lineal Diſtance of 90 upon the Line of Sines :

Set that a diagonal Diſtance from 60 to 60 on the Lines of Sines :

Then the lineal Diſtance of 23.30 on that Line of Sines, will give you the diagonal Diſtance 20.12 = *rt* on the Sines.

But it is not pretended that all the 28 Caſes of ſpheric Triangles can be done the beſt way by this Inſtrument, of which I have ſhewed the Uſe, &c. much more than I have ſeen done before, and in a more natural Method.

SECT.

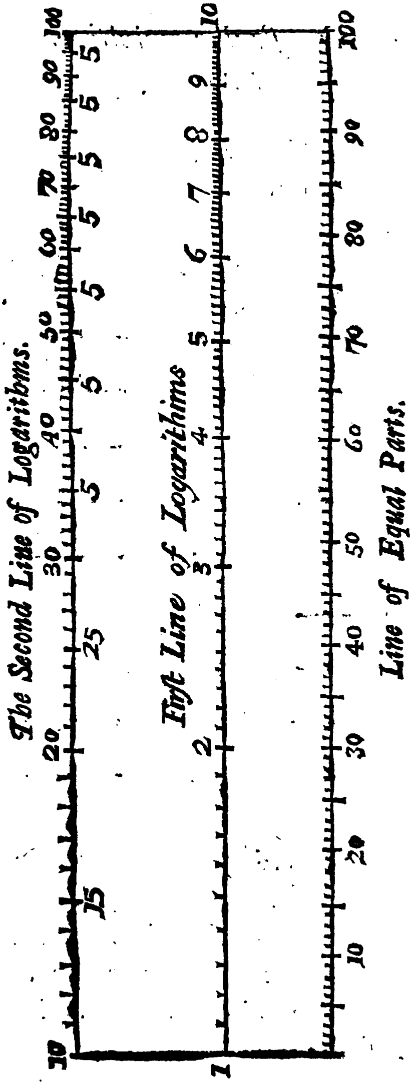
SECT. VI.

The Making, Deſcription, *and* Uſe *of the* Line of Numbers, *or* Logarithms, *commonly called* Gunter's-Line.

I. *For the great Diviſions on the firſt Line.*

Take from the Line of equal Parts theſe Logarithms,	*Which are Logarithms of theſe Numbers,*	*And ſet them from* 1 *on the Line of Numb. to the ſame.*
.301	2	2
.477	3	3
.602	4	4
.698	5	5
.778	6	6
.845	7	7
.903	8	8
.954	9	9

The


The Second Line of Logarithms.
First Line of Logarithms
Line of Equal Parts.

II. *For the ſmaller Diviſions on the firſt Line.*

Take from the Line of equal Parts theſe Logarithms,	*Which are Logarithms of theſe Numbers,*	*And ſet them from* 1 *on the Line of Numb. to the ſame.*
.041	1.1	1.1
.079	1.2	1.2
.113	1.3	1.3
.146	1.4	1.4
.176	1.5	1.5
.204	1.6	1.6
.230	1.7	1.7
.255	1.8	1.8
.278	1.9	1.9

And ſo proceed with the Logarithms of 2.1, 2.2, 2.3, *&c.* and 3.1, 3.2, 3.3, *&c.* to 9.9. And when you have thus finiſhed the firſt Line, you may ſet the ſame upon the ſecond Line, which beginning where the firſt endeth (the 10 at the Top of the firſt and the Bottom of the ſecond being coincident) is continued in one right Line with the firſt, and number'd, as you ſee, from 10 to 100.

Such as know little of Logarithms, may note,

That the Log. of 1.1 is the ſame with that of 11, 1.2 with that of 12, *&c.* omitting Indexes.

Thus having fully ſhewed how a Line of Numbers or Logarithms are made to any Radius whatever, (for that, as you ſee, depends on the Length of the equal Parts) I ſhall give this farther.

II. *Deſcription of the Line of Numbers.*

It is a Line divided into twice 90 unequal Parts. The firſt 90 is from 1 to 10, and the ſecond Part is number'd from 10 to 100. And if you reckon the firſt Part 10, 20, *&c.* to 100, then you muſt ſuppoſe the ſecond Part from 10 to 100, to be 100 to 1000, *&c.* As will appear farther in

III. *The Uſe of the Line in Multiplication, &c.*

QUESTION I.

What is the Product of 9 times 8?

Extend the Compaſſes from 1 to 8, and the ſame will reach from 9 to 72 in the ſecond Part.

QUEST. II.

What is the Product of 20 by 40?

Here if you ſuppoſe the Beginning of the Line 10, then 2 is 20; to which extend the Compaſſes, and the ſame Extent will reach from 40 to 800. Or it may be done more plainly on the ſecond Part of the Line.

QUEST. III.

What is the Content of a Plank whoſe Length is 4 $\frac{1}{4}$, and the Breadth 1 $\frac{3}{4}$?

Extend the Compaſſes from 1 to either Dimenſion, and the ſame will reach from the other to 7.43.

QUEST. IV.

How many ſquare Feet is there in a Table whoſe Length is 23.5 Foot, and Breadth 2.5 Foot?

Extend the Compaſſes from 1 to 2.5, and the ſame Extent will reach from 23.5 to 58¾.

QUEST. V.

What is the Product of 7 s. 6 d. multiplied by 3 s. 9 d.?

The Pence in both being put in Decimals of a Shilling; then the Queſtion will be to multiply 7.5. by 3.75. Therefore extend the Compaſſes from 1 to 3.75, and the ſame Extent will reach from 7.5 to 28.125, or 28 *s.* 1½ *d.* the true Anſwer: As appears plain; for 3 *s.* by 7 *s.* is 21 *s.* and the Fractions multiplied, make the Product 28.125, or 7 *s.* 1½ *d.* more.

IV. *The Uſe of the Line of Numbers in Diviſion.*

QUEST. I.

What is the Quotient of 72 *divided by* 9?

Extend the Compaſſes from 1 to 9, and the ſame Extent will reach backward from 72 to 8, the Anſwer. And this is the Rule for all.

QUEST. II.

What is the Quotient of 800 *divided by* 40?

Extend the Compaſſes from 1 to 4, or 10 to 40, and the ſame Extent will reach from 800 backward to 20. = the Anſwer.

QUEST. III.

The Content of a long ſquare Plank or Board, is 7.43 *Foot, the Length is* 4 ¼; *What is the Breadth?*

Extend the Compaſſes from 1 to 4.25, and the ſame Extent will reach from 7.43 backward, to 1.75. = the Anſwer.

QUEST.

QUEST. IV.

A Table contains 58.75 Feet, and the Breadth is 2.5 Feet; What muſt be the Length of ſuch a long ſquare Table or Parallelogram?

Extend the Compaſſes from 1 to 2.5, and the ſame will extend backward from 58.75 to 23.5. = the Length, or Anſwer.

QUEST. V.

There are two Sums, containing each a certain Number of Shillings and Pence; which being multiplied together, produce 28 s. 1 d. ½. *One of the Sums is* 3 s. 9 d.: *What is the other?*

Extend the Compaſſes from 1 to 3.75, and the ſame Extent will reach backward from 28.125 to 7.5, or 7 *s.* 6 *d.* The Anſwer.

Note, Theſe five Queſtions above in Diviſion, prove thoſe five in Multiplication: I ſhall now proceed to ſome Queſtions done by Multiplication and Diviſion; or ſhew,

V. *The Uſe of the Line of Numbers, in the direct Rule of Proportion.*

QUEST. I.

What is the 4th Proportional to 13, *when it is as* 2 *bears proportion to* 6?

Extend the Compaſſes from 2 to 6 in the firſt part of the Line, and the ſame Extent will reach from 13 to 39, the Anſwer, in the ſecond part of the Line.

QUEST. II.

Suppoſe 120 *is in proportion to ſome Number, as* 30 *is to* 80, *what is that Number?*

Extend the Compaſſes from 30 to 80 on the firſt Line (calling 1, 10; 2, 20, *&c.*) and the ſame Extent will reach on the ſecond Line from 120 (calling 10, 100; and 2 of the ſmaller Diviſions 20) to 320 very plainly.

QUEST. III.

What is the Intereſt of 165 *Pounds for a Year, at the rate of* 5 per Cent.?

Extend the Compaſſes backward from 100 (calling 10 at the beginning of the ſecond Line ſo) to 5 on the firſt Line, and the ſame Extent will reach backward from 165 on the ſecond Line, to 8.25 on the firſt Line, which is 8 and a quarter, or 8 *l.* 5 *s.* = the true and plain Anſwer:

Or; as, 100 : 50 : : 165 : 82.5.

But becauſe the Intereſt is but a 10th Part of 50; I therefore take but a 10th of the 4th Proportional 82.5, which is 8.25, or 8 *l.* 5 *s.* as is ſaid before. I mention this, that you may ſee the Lines agree with the Deſcription above.

QUEST. IV.

What is the Intereſt for Half a Year, of 330 *l.* 10 *s.* *at the rate of* 6 per Cent.?

Extend the Compaſſes backward, from the beginning of the ſecond Line (calling it 100 as before) to 3 (which is half a Year's Intereſt) in the firſt Line, and the ſame Extent reaches from 330 *l.* 5 *s.* on the ſecond Line, to 9.915 on the firſt Line; for,

As, 100 : 30 : : 330.5 : 99.15

A 10th of which laſt is 9 *l.* 18 *s.* 3 $\frac{1}{2}$ *d.*

QUEST. V.

If 560 lb. *of Sugar coſt* 115 *Shillings, what did the* 112 lb. *coſt?*

Extend the Compaſſes from 560 to 115 on the ſecond Line (calling 10, 100, &c.) and the ſame Extent will reach from 112 on the ſecond Line, to 23 on the firſt Line; ſo is 23 *s.* the Anſwer.

VI. *The Uſe of the Line, in the ſingle Rule of Proportion Reverſe.*

QUEST. I.

How much Stuff of 3 *Quarters broad, will line* 5 *Yards of Cloth that is* 7 *Quarters broad?*

Extend the Compaſſes from 3 to 5, and the ſame Extent will reach from 7 (all on the firſt Line) to 11$\frac{2}{3}$ on the ſecond Line.

QUEST. II.

How many Yards of Black Cloth of 7 *Quarters wide, will hang a Room that is* 46 *Yards round, and* 4 *Yards high.*

Extend the Compaſſes from 7 Quarters in the firſt Line to 46 Yards on the ſecond Line, and the ſame Extent will reach from 16 Quarters high, to 105$\frac{1}{7}$ (the firſt on the firſt Line, calling 1, 10; and the 105$\frac{1}{7}$ on the ſecond Line, ſuppoſing 10 to be 100)

QUEST. III.

Suppoſe when the Price of a Buſhel of Wheat is 6 s. 3 d. *the Penny Loaf ſhall weigh* 9 *Ounces; what muſt ſuch Loaf weigh, when the Buſhel of Wheat is* 4 s. 2 d.?

Extend the Compaſſes from 4 *s.* 2 *d.* (or 50 *d.*) to 9; and the ſame Extent will reach from 6 *s.* 3 *d.* (or 75 *d.*) to 13,5 Ounces. = the Anſwer.

QUEST. IV.

If a certain Quantity of Proviſion will ſerve 400 *Men for* 6 *Months, how many Men will the ſame Quantity ſerve for* 7 *Months?*

Extend the Compaſſes from 7 on the firſt Line to 40 (calling it 400) on the ſecond Line; and the ſame Extent will reach from 6 on the firſt Line to 343 *(ferè)* on the ſecond Line; which is the Anſwer.

QUEST. V.

If I lend 200l. *for* 8 *Months; how long muſt* 150 l. *be lent me to retaliate my Favour, without Loſs to either Party?*

Extend the Compaſſes from 150 on the ſecond Line (calling 10, 100, *&c.*) to 8 Months on the firſt Line, and the ſame Extent will reach from 200 on the ſecond Line, to 10⅔ Months on that Line. = the Anſwer.

VII. *The Uſe of the Line of Numbers in extracting the Square Root,* &c.

If the Sum be 100 or more, whoſe Root you would know, do it by the upper or ſecond Line; but if leſs, do it by the firſt Line.

And if you point over Unit's Place, and ſo over every other, the Points will ſhew the Places that the Root is to have.

QUEST. I.

What is the Square Root of 40000?

Fix your Compaſſes at 40000 (calling 10, 10000) and take Half the Diſtance between that and 10, which will fall at 20; and becauſe by the Rule above, 40000 would have three Points over; therefore this 20 muſt be 200, or have three Places, and ſo is 200 the Square Root of 40000, found very plainly and accurately.

QUEST. II.

What is the Square Root of 144?

Take half the Diſtance between 144 and 10, which will fall at 12, the Root. And if it were required to ſquare any Number, extend the Compaſſes from 1, or 10, &c. to that Number, and on that Point turn the Compaſſes, and the other Point will fall on the Square required. Thus,

QUEST. III.

What is the Square Root of 200°?

Extend the Compaſſes from 10, calling it 100, &c. to 20 or 200, and giving the Compaſſes a Turn on that Foot, the other will extend to 40000.

QUEST. IV.

Having any two of the three Sides of a right-angled plain Triangle, to find the third? As ſuppoſe the Hypothenuſe be 50, the Baſe 40, and the Perpendicular is required?

By the laſt Rule, ſquare 50, which is 2500, and from that take the Square of 40, which is 1600, and the Remainder is 900; to which ſet one Foot of your Compaſſes, and half the Diſtance to 10 is 30. = the Anſwer, or Perpendicular. By 47, 1 *Euclid.*

QUEST. V.

Suppoſe the Area of an Ellipſis, or other irregular Figure be 552.25; and I would know the Side of a Square, equal to the Ellipſis?

Set one Foot of the Compaſſes (as hath been taught) in the ſecond Part of the Line, and take half the Diſtance thence and 10, which Half will fall at 23.5 the Side of the Square required.

VIII. *The Uſe of the Line of Numbers, in extracting the Cube-Root.*

QUEST. I.

What is the Cube-Root of 1728?

Extend the Compaſſes on the ſecond Line, calling 10, 1000, to a third of the Diſtance between 1728 and 10; then turn the Compaſſes towards 10 from the 1728, is one Third of the Diſtance;

Diſtance, and again, the ſecond Turn, or two Thirds, is the Cube-Root ſought = 12.

Note, If the Sum, whoſe Cube-Root you know, be 1000 or upward, do your Operation by the ſecond or upper Line; but if leſs, by the firſt Line.

And if you point over Unit's Place of the Sum given, to have its Root extracted, and over every Third, the Points will ſhew the Places that the Root will conſiſt of.

QUEST. II.

What is the Cube-Root 8000?

By the Rule above of Pointing, it is plain that the Root muſt have two Places; therefore ſetting your Compaſſes at 8000 (calling that 10 at the beginning of the ſecond Part of the Line 1000, *&c.*) divide the Diſtance from that to 16, into three equal Parts; the End of the ſecond Part next 10 from 8000 is 20, the Cube-Root required.

QUEST. III.

For Proof of the laſt Queſtion; I ſay, What is the Cube of 20?

If you extend the Compaſſes from the beginning of the ſecond Part of the Line to 20, giving the Compaſſes two Turns; the firſt will extend from 20 to 400, = the Square of 20; and the ſecond Turn will extend from 400 to 8000, = the Cube of 20, or 20 times 400; and thus may the Cube-Root of any other Number be proved to be true. For, as in the laſt Example; becauſe the Root conſiſts of two Places, every Turn of the Compaſſes will increaſe by 10, and the Figure it extends to: So that 20 is made 400, and 400, 8000, &c.

QUEST. IV.

If a Sphere be 56 lb. weight, whoſe Diameter is 6 Inches; what is the Diameter of another Sphere of the ſame Matter, whoſe weight is 40lb.?

Extend the Compaſſes from 56 to the Cube of 6 (which is 216) and the ſame Extent will reach from 40 to 154.3 *ferè*.

Then ſet one Foot of the Compaſſes at 154.3 and two Thirds of the Diſtance from that to one backward, will fall at 5.36. The Anſwer.

And ſo much for the Uſe of the Line, its Deſcription and Making; which is more full and ample than has been done, I believe.

And it may be noted, That as the Weight, ſo the Solidity of Spheres are in a triplicate Ratio of their Diameters.

SECT. VII.

Myſterious CURIOSITIES *in* Numbers; *or*, Numerical Novelties.

PROPOSITION I.

THERE is a Number conſiſting of nine Digits; which being multiplied by five different Digits, each of the five Products ſhall have the nine Digits in it, and neither more nor leſs; and the Sum of the five Products ſhall contain the 9 Digits and 0, which are the Characters by which all Numbers whatſoever are expreſſed.

EXAMPLE.

The Number propoſed is —— 123456789

Which multiply'd by 2 produceth 246913578
4 —— 493827156
5 —— 617283945
7 —— 864197523
8 —— 987654312

Theſe have each juſt the 9 Digits.

3209876514 = Sum, for 9 Digits and 0.

PROP. II.

There is a Number conſiſting of 9 Digits, as the former, but inverted; which being multiplied by 5 different Digits, each of the 5 Products will have in it neither more nor leſs than the 9 Digits and Cypher; or each of the Products will have in it the ſame Characters that were in the Sum of the Products in the laſt *Propoſition*, neither more nor leſs.

EXAM-

EXAMPLE.

The Number propoſed is ——— 987654321

Which multiply'd by	8	produceth	7901234568	*Theſe have each juſt the 9 digits & Cypher.*
	7	———	6913580247	
	5	———	4938271605	
	4	———	3950617284	
	2	———	1975308642	

And the Sum of theſe Products hath the 9 Digits and Cypher, except the 8, which it ſplits into 6 and 2. But if the Number propounded be multiplied by 9, the Product will be all Eights, only one Nine. And if that laſt Product be added to the ſaid Sum, that Total will have the 9 Digits again, except the 8, which it divides into 5 and 3.

PROP. III.

A Number conſiſting of the 9 Digits naturally aſcending, being divided by 2 and by 5, will exhibit 2 Quotients each, having the 9 Digits in it: And the Sum of thoſe two Quotients hath alſo juſt the 9 Digits, and no more

nor

not leſs (allowing a 0, by way of Decimal, in the Dividend.)

EXAMPLE.

The Number proposed is = 123456789

2) 61728394.5 = firſt Quot.

5) 24691357.8 = ſecond Quot.

The Sum of which Quotients is = 86419752.3, which is juſt the 9 Digits: And the like will ariſe from no other Diviſors.

PROP. IV.

If the 9 Digits naturally aſcending, as before, be divided by 4, the Quotient will be the 9 Digits and 0; which is all the Characters that any Number is expreſſible by, and which will ariſe from no other Diviſor whatever, more or leſs.

EXAMPLE.

4)123456789(30864197.25 = Quot.

PROP. V.

If the 9 Digits naturally deſcending, be divided by 2 and by 5, the Quotients will each have juſt the 9 Digits and 0; and the Sum of thoſe two Quotients will alſo be the 9 Digits and Cypher, or all the Characters by which any Number may be expreſſed.

Now this is the more ſtrange, becauſe 5 is a prime Number, and no Multiple of any.

EXAMPLE.

2)987654321(4938271605 = 1 Quot.

5) - - - - - - 1975308642 = 2 Quot.

Sum of Quotients = 6913580247

PROP. VI.

And now I am upon the 9 Digits; it may be obſerved, that if they be multiplied any way one in another, (or, as one ſaid, jumbled together) the laſt Product ſhall however exhibit all the Number of Changes that can poſſibly be ranged on 9 Bells.

EXAMPLE.

Bells 1

Multiply'd by 2 gives 2 Changes

2 by 3 —— 6

4 —— 24

5 —— 120

6 —— 720

7 —— 5040

8 — 40320

9 — 362880 = Changes on 9 [Bells.

PROP. VII.

By placing 14 Figures to the greateſt Advantage, there may be ſhewed not only the Numbers to be multiplied, but the Products ſufficient for any *Multiplication Table*.

This Method, as a Curioſity in Numbers, I contrived about fourteen Years ago; and as follows, do give an

EXAMPLE.

Multiply 2 of theſe.	*Given 2 of theſe to be multiplied.*	*Add 2 of theſe.*
1	9	40
2	8	30
3	7	20
4	6	10
5	5	

So if it were required to know the Product of 9 times 8.

	In the Middle,	*To the Right*	*To the Left.*	
Againſt - - -	9 & 8 is	40 & 30, or 70,	& 1&2,	=72
So 9 times 7 -	9 & 7 is	40 & 20=60,	& 1&3,	=63
9 times 6 -	9 & 6 is	40 & 10=50,	& 1&4,	=54
8 times 7 -	8 & 7 is	30 & 20=50,	& 2&3, or 6	=56
8 times 6 -	8 & 6 is	30 & 10=40,	& 2&4, or 8	=48

And ſo on.

Alſo to ſquare or multiply any in the Middle by it ſelf, as 9.

In the Middle,

Againſt 9 ſtands 40, doubled is 80, & the 1 by 1 is 1=81
8 by 8 - 8 30, 60, & the 2 by 2 is 4=64
7 by 7 - 7 20, 40, 3 3=9=49

And ſo on.

PROP. VIII.

The Number 362880 may be continually divided by a different Digit from 1 to 9 incluſive, and no Remainder ſhall be of any of the Dividends, which cannot be ſaid of any other Number.

EXAMPLE.

3) 4)
2)362880(181440(60480(15120

6) 7) 8)9)
5)15120(3024(504(72(9(1 Quot. Rem. 0
[of all.

PROP. IX.

The Sum of an infinite Progreſſion (which may be thought very unaccountable) may be found in Numbers.

EXAMPLE *of the Series*, &c.

768, 192, 48, 12, 3, $\frac{3}{4}$, $\frac{3}{16}$, $\frac{3}{64}$, $\frac{3}{256}$, *&c.* *ad infinitum.*

Here the Ratio is 4 : Therefore,

As the Ratio leſs 1 :

Is to 1 : :

So is the firſt Term :

To the Sum of all the reſt of the Terms.

Thus,

3 : 1 : : 768 : 256 = the Sum of the reſt
768 more the firſt Term.

1024 = the Sum of all, tho' the Progreſſion had been continued to 10000 Terms lower.

PROP. X.

A Perſon comes into a Bookſeller's (who was an Accomptant) and asks the Price of a Book, which he was told was 5 *s.*: But he not willing to give it, the Bookſeller told him there were 100 Leaves in it, and if he would give a Pin (of 4 Rows a Penny, and 18 to the Row) for the

the firſt Leaf, 2 for the ſecond, *&c.* to 100 incluſive, he ſhould have the Book: Which the Buyer willingly accepting, the Value was computed by this Rule in Progreſſion.

Multiply the laſt (here the 100*th Term) by the Ratio* 2, *and from that deduct the firſt Term (here* 1); *divide the Remainder by the Ratio, leſs* 1, *and the Quot. is the Sum of all the Terms of the Progreſſion.*

EXAMPLE.

By Multiplication, the 100th Term is equal to

633825300114114700748351602688

Which multiplied by 2, and 1 abated, gives the Sum of all the Terms, equal to

1267650600228229401496703205375 *Pins.*
[Reſts 15 *Pins.*

Which divided by 72, the Pins for 1*d.* gives equal to

17606258336503186131898655630 *Pence.*
[Reſts 2 *d.*

Which divided by 12, gives

1467188194708598844324887969 *Shillings.*

Which reduced into Pounds, gives the Sum to be paid for the Book by Agreement,

73359409735429942216244398*l.* 9*s.* 2*d.* 15 *Pins.*

A Sum ſo great, that Monſieur *Bibliopol.* would be content to abate the fifteen Pins, to be informed how he might come at ſo much of the reſt as would not be inconſiſtent with his living out of *M. Fields* : For, according to the Computation of 300,000,000 of People in the World, it would furniſh each with an Eſtate of more than 244,531,365,784,766,474 *l.* ſo wonderfully incredible does this Way of computing increaſe ſmall and inconſiderable Things: As in this Inſtance, from a Pin to a Sum more than the World is worth.

PROP. XI.

A Row of Decimals infinitely repeated, and, if you pleaſe, Integers prefixed, may be multiplied by the like, and the true Product is exhibited by a very few Figures. Thus, Multiply 5·33333333333333, &c.

by 6.66666666666666, &c.

3.20 I add theſe 10's to 100's, &c.

3.5 *r* Sum } Add
32.0 }

Product = 35·55555555, &c.

PROOF.

$5\frac{1}{3}$ is = $\frac{16}{3}$

$6\frac{2}{3}$ is = $\frac{20}{3}$

Now $\frac{16}{3}$ by $\frac{20}{3}$ is = $\frac{320}{9}$

Which $\frac{320}{9}$ is = $35\frac{5}{9}$

Or = 35,5, repeated *ad infinitum*, as before.

This is a Curioſity which I have but lately contrived, but is yet more briefly done under the next *Propoſition.*

There are three curious Myſteries in the foregoing *Propoſition.*

Firſt, That multiplying only the Prime's Place of the Decimals in each Factor ſhould be made ſufficient, by adding 2, to give a Number, (as here 320:) Which,

Secondly, Being added from the Right Hand toward the Left, ſhould give the true Product (as here 8 and 5 repeated;) it being contrary to the general Rules given by all, to add Units to Tens, and thoſe to Figures in the Hundreds Place, &c. And,

Thirdly, That the Sum of the two laſt Figures in the Line ſhould be a Repeater in the Product.

PROP. XII.

If Integers and Decimals are repeating Digits in the Multiplier; and if you multiply by one of the Repeaters, and the Product from the Right Hand toward the Left being added, and the Sum of the two laſt having Tens added to Units, the Sum will be the repeating Decimal of that Product. And ſo many of that Repeater as there are Integer-Places in the Multiplier, being put toward the Left Hand of the Point, you have the true Product, by making only one Line before it.

EXAMPLE.

Multiply 54321,
by 6666666666666666666, *&c.*

325926 Add theſe Units to Tens, *&c.*

Prod. = 362139999·999999999999999, *&c.* done [by 85 Figures fewer than the common Way.

In this *Example*, (beſides the three Myſteries under the laſt *Propoſition* mention'd) here is a fourth; *i. e.* That there ſhould always be ſo many repeating Digits toward the Left Hand from the Point (of the ſame kind as thoſe toward the Right Hand of it) as there are Repeaters towards the Left-Hand of the Point in the Multiplier.

In like manner the *Example* under the 11th *Propoſition* might have been done (notwithſtanding the great Number of Decimals in each Factor) by making only one Line (inſtead of three) beſides the Product.

PROP.

PROP. XIII.

But if the Multiplier were repeating Integers, then the firſt Line muſt be added in another Way to obtain the Product.

EXAMPLE.

54321
by 6666

Add this 325926

362103786 = Product.

PROOF.

The Product of = 54321
by .6 repeated

Is, as ſhew'd before = 36213.999, &c.

To which adding the Product, as in this laſt *Example*, = 362103786

The Sum is = 362139999.9999, &c.

As in the *Example* above, which proves both that and theſe to be true.

Here to add the Line, I ſay 6; Then 6 and 2 is 8 in the Product: Then 6 and 2 is 8, and 9 is 17; 7 put down: Then 1 I carried, and 6 is 7, and 2 is 9, and 9 is 18, and 5 is 23; put down 3, and carry 2: Then, becauſe you have added as many as there are Places in the Diviſor, leave out the 6 in Unit's Place, and ſay, 2 carried, and 2 is 4, and 9 is 13, and 5 is 18, and 2 is 20; put down 0, and leave 26 out: and ſay, 2 carried, and 9 is 11, and 5 is 16, and 2 is 18, and 3 is 21; put down 1, and carry 2: and ſay, 2 and 5 is 7, and 2 is 9, and 3 is 12; I put 2 down, and carry 1, and 2 is 3, and 3 is 6; which put in the Product, and 3 is 3 there.

The Proceſs here being a little intricate, becauſe new, I have directed you through the whole, proved as in the foregoing *Page*.

Note, That this is done by 18 Figures in 24 fewer than the common Way.

PROP. XIV.

How to avoid all unneceſſary Figures in an Operation and Product, when there are many decimal Places in one or both Factors to be multiplied together, and yet to give an accurate Rectangle, as by the common Way.

EXAM-

EXAMPLE I.

Multiply 1.23456 by 9.87654, ſo that there may be put 4 decimal Places in the Product, and yet they to be as valuable as if the whole Factors had been multiplied in the common Way.

$$\begin{array}{r} 1.23456 \\ \underline{45678.9} \\ 111110 \\ 9876 \\ 864 \\ 74 \\ 6 \\ \underline{1} \\ 12.1931 \end{array}$$

12.1931 = the true Product, with fewer Figures than the common Way, by 20 in 37.

EXAMPLE II.

Multiply .12345 by .98765, and to have 4 Decimals only in the Product, which ſhall have 4 Places next the Point (which in moſt Caſes are ſufficient) as true as if all had been unneceſſarily multiplied.

```
 .12345
 56789.
 ------
 1111
   99
    8
    1
 ------
 .1219 = Product, with 22
```

Figures in 30 fewer than the common Way.

Note, 1. In this Way of Multiplication I revert the Multiplier.

2. I put Unit's Place thereof under that decimal Place of the Multiplicand which anſwers to the Number of Decimals that I would have in the Product.

3. I only multiply the Figures which ſtand over that Figure I multiply by.

4. But I conſider what would be carried, if two, or at leaſt one of the Figures next the Right Hand of that which I multiply, were multiplied.

5. I place the Surplus above 10 of each Figure, which I firſt multiply, one under another, all next the Right Hand, and

not a Place more toward the Left Hand, as in the common Way.

By theſe *Notes* any one, I think, may perform Multiplication this Way.

PROP. XV.

To know the Chances that may be thrown on any Number of Dice, from 1 to 6, is as by this *Table* of 1, 2, 3, *&c.* to 6.

TABLE I.

Dice							
1	1	2	3	4	5	6	Roots, or Points on one Side.
2	1	4	9	16	25	36	Squares.
3	1	8	27	64	125	216	Cubes.
4	1	16	81	256	625	1296	Biquadrates.
5	1	32	243	1024	3125	7776	Surſolids.
6	1	64	729	4096	15625	46656	Squar'd Cubes.

The uppermoſt Figures involved, produce the Powers under them.

The Right-Hand Column ſhews the greateſt Number of Chances that is on any Number of Dice from 1 to 6. That under 5 is the Number without a 6; that under 4, the Number without 5 and 6, *&c.*

And that this is no more ſtrange than true, I will demonſtrate ſeveral Ways that the greateſt Number of Chances on two Dice is 36. = the Square of the greateſt Number of Points on one Side of a Dice.

The particular Chances on two Dice are thus:

TABLE II.

1,1	2,1	3,1	4,1	5,1	6,1
1,2	2,2	3,2	4,2	5,2	6,2
1,3	2,3	3,3	4,3	5,3	6,3
1,4	2,4	3,4	4,4	5,4	6,4
1,5	2,5	3,5	4,5	5,5	6,5
1,6	2,6	3,6	4,6	5,6	6,6

6 + 6 + 6 + 6 + 6 + 6 = 36 [in all.

Note, + ſignifieth *more*, and = *equal to*.

A ſecond Way thus:

TABLE III.

1,1	1,2	2,3	3,4	4,5	5,6
2,2	1,3	2,4	3,5	4,6	——
3,3	1,4	2,5	3,6	——	1
4,4	1,5	2,6	——	2	+2
5,5	1,6	——	3		+3
6,6	——	4			+4
——	5				+5
6					+6
					——
					= 21 Sum.

Farther,

2,1	3,2	4,3	5,4	6,5
3,1	4,2	5,3	6,4	——
4,1	5,2	6,3	——	+1
5,1	6,2	——	+2	2
6,1	——	+3		3
——	+4			4
5				5
				——

Chances = 15 + 21 =
[36, as before.

TABLE

TABLE IV.

A third Way for particular Chances on two Dice.

Casts.	Points.	Chances.
2	1,1	1
3	2,1	2
	1,2	
4	2,2	3
	1,3	
	3,1	
5	4,1	4
	1,4	
	3,2	
	2,3	
6	5,1	5
	1,5	
	4,2	
	2,4	
	3,3	
7	6,1	6
	1,6	
	5,2	
	2,5	
	4,3	
	3,4	
		21 = Sum

Caſts.	*Points.*	*Chances.*
8	4,4	5
	6,2	
	2,6	
	5,3	
	3,5	
9	6,3	4
	3,6	
	5,4	
	4,5	
10	5,5	3
	4,6	
	6,4	
11	6,5	2
	5,6	
12	6,6	1

Sum 15 + 21
[=36, Sum Total as before.

Alſo in farther Uſe of *Table* I. to demonſtrate that the Chances anſwer to the Number of Points in the uppermoſt Line, and the Number of Dice in the Left-Hand Column. Thus againſt 2 Dice, and under 3, ſtands 9; which ſhews that there are 9 Chances on 2 Dice, when the greateſt Number of Points are but 3 on thoſe Dice.

Demonſtrated thus:

Points.

$$\left.\begin{array}{l} 1 \,\&\, 1 \\ 2,\ 2 \\ 3,\ 3 \\ 1,\ 2 \\ 2,\ 1 \\ 1,\ 3 \\ 3,\ 1 \\ 2,\ 3 \\ 3,\ 2 \end{array}\right\} \text{Sum} = 9 \text{ Chances.}$$

Secondly, That there are but 8 Chances on 3 Dice, when the greateſt Number of Points thereon is 2. Thus,

Points.

$$\left.\begin{array}{lll} 1 \,\&\, & 1 \,\&\, & 1 \\ 2, & 2, & 2 \\ 2, & 1, & 1 \\ 1, & 1, & 2 \\ 1, & 2, & 1 \\ 2, & 1, & 2 \\ 2, & 2, & 1 \\ 1, & 2, & 2 \end{array}\right\} \begin{array}{c} \text{Sum} = 8 \text{ Chances,} \\ \text{as by the \textit{Table}.} \end{array}$$

Thirdly, That there 27 Chances on 3 Dice, when the greateſt Number of Points thereon is 3. Thus,

Points.		*Chances.*
1, 1, 1	———	1
2, 2, 2	———	1
3, 3, 3	———	1
1, 2, 2	———	2
1, 3, 3	———	2
1, 2, 3	———	2
1, 2, 1	———	1
1, 1, 2	———	2
1, 1, 3	———	2
1, 3, 1	———	1
2, 1, 2	———	1
2, 3, 2	———	1
2, 3, 3	———	2
2, 1, 3	———	2
2, 3, 1	———	2
3, 1, 3	———	1
3, 2, 2	———	2
3, 2, 3	———	1

27=Sum Total.

PROP. XVI.

The Unciæ of Powers algebraically involv'd are the Figures which ſtand towards the Left Hand of the ſeveral Members of the ſeveral Powers: As $a+b$ being multiplied in it ſelf, gives $aa+2ab+bb$; that is, 1 a ſquared, more 2 ab, (or twice a multiplied in b) more 1 b ſquared.

And where the Unciæ are but 1, they are not put down, but ſuppoſed; and ſo the Cube, Biquadrate, and Surſolid are as follow:

$a+b$

Multiplied by - - $a+b$

Gives $aa+2ab+bb$ = the Square of $a+b$.

Multiplied by - - - - - $a+b$

Gives $aaa+3aab+3abb+bbb$ = the Cube.

Multiplied by - - - - - - - - - - $a+b$

Gives $aaaa+4aaab+6aabb+4abbb+bbbb$ = the [Biqu.

Multiplied by - - - - - - - - - - - - - - - - - - $a+b$

Gives $aaaaa+5aaaab+10aaabb+10aabbb+5abbbb+bbbbb$ = [the Surſolid.

Here in this Surſolid, or fifth Power of $a+b$, it is plain the Unciæ are 1, 5, 10, 10, 5, 1. Now there is a Rule to find theſe Numbers without multiplying the Species, thus:

$$1\times\frac{5-0}{1}(5\times\frac{5-1}{2}(10\times\frac{5-2}{3}(10\times\frac{5-3}{4}(5\times\frac{5-4}{5}(1$$

That is,

1 multiplied in 5 leſs 0, divided by 1 = 5
5 ———————— 5 — 1 ———— 2 = 10
10 ———————— 5 — 2 ———— 3 = 10
10 ———————— 5 — 3 ———— 4 = 5
5 ———————— 5 — 4 ———— 5 = 1

Secondly, But there is a briefer Way of finding the Unciæ, and only by Addition, which is my own Thought, thus:

1, 1 = the Unciæ of the Root.
1, 2, 1 = that of the Square.
1, 3, 3, 1 = that of the Cube.
1, 4, 6, 4, 1 = that of the Biquadrate.
1, 5, 10, 10, 5, 1 = that of the Surſolid.
1, 6, 15, 20, 15, 6, 1 = that of the ſquared Cube, &c.

Here 2 added from the Right toward the Left, gives thoſe in the Middle reſpectively, and the 1's at each End of a Line put down as they are. Thus for the Unciæ of the Square; 2 in the Middle is the Sum of 1 and 1 above: For the Cube, 2 and 1 = 3, and 1 and 2 = 3, and 1 and 1 next the Right and Left: And in the Biquadrate from the Unciæ of the Cube, I ſay, (1), 3 and 1 is (4), 3 and 3 is (6), 1 and 3 is (4), and (1) always to the Right and Left; thoſe in ( ) being the Unciæ, which are ſoon found.

Thirdly, But that which I chiefly inſiſt upon as a Curioſity (under this *Propoſition*) is the Rule for finding the Unciæ of any Member of any Power, without knowing thoſe of the preceding Powers or Members.

This is alſo my own Invention: Altho' near ſeven Years afterward I ſaw a Rule very near it, uſed by an ingenious Author on another Occaſion, not this.

To find the Unciæ of the fourth Member, or Term, of the ſixth Power, put down the Digits to within 1 of the given Member, and multiply them together for a Diviſor.

As here 1 by 2 by 3 is = 6, the Diviſor.

Then put down as many Figures downward from the Power, as here, 6, 5, 4; which multiply together for a Dividend = 120, and the Quotient will be = 20, the Unciæ ſought: As appears by the laſt *Table*.

So alſo the Unciæ of the 3d Term of the 4th Power will be found 6:

For, 1 in 2 is 2, the Diviſor.

And, 4 in 3 is 12, the Dividend, Quot. = 6 [Anſw.

So alſo the Unciæ of the 4th Term of the 5th Power is 10:

For, 1 in 2 in 3 = 6, the Diviſor.

And, 5 in 4 in 3 = 60, the Dividend.

Quot. is as above.

So, laſtly, the Unciæ of the 10th Term of the 15th Power is thus found:

1 in 2 in 3 in 4 in 5 in 6 in 7 in 8 in 9 = [Diviſor.

And, 15 in 14 in 13 in 12 in 11 in 10 in 9 in 8 in 7 = [Dividend.

Thus,

For Diviſor multiply	*For Dividend multiply*
1	15
2	by 14
2	210
by 3	by 13
6	2730
4	12
24	32760
5	11&10
120	3603600
6	9
720	32432400
7	8
5040	529459200
8	7
40320	*81621440.0=Dividend.
9	181440 (5005 =Anſw.
	or [or Quot.
36288.0 = Diviſor.	

So that, according to the new Rule above, the Unciæ of the tenth Term, or Member, of the fifteenth Power, is 5005.

And if the greateſt Man that ever was, thought it neceſſary to give the Rule under and at the End of the firſt Head of this *Propoſition*, I hope the two New Methods under the ſecond and third Heads (being much briefer and eaſier) will be taken as a great Improvement and Curioſity.

PROP. XVII.

For finding the Gallons in the Decimal of a Barrel of Beer, I have contrived the following curious and briefer Method than the common of multiplying by 36.

EXAMPLE I.

.6543 of a Barrel.
26.172
23.5548 Gallons and Parts.

EXAMPLE II.

.4321 of a Barrel.
1.7284
15.5556 Gallons and Parts.

Here I only multiply the given Decimal by 4, and ſubtract the Product from it ſelf, as Units from 0, Tens from Units, *&c.* having firſt cut off from the Product one Place leſs than in the Decimal given.

So that as in former *Propoſitions* I have given the Anſwer by adding, ſo here by ſubtracting one and the ſame Line, Tens from Units, *&c.* A Thing never ſhewed by any other before, and what may be thought unaccountably curious by an impartial Reader.

For briefly Valuing Decimals of Money, Weight, or Meaſure, by Inſpection.

PROP. XVIII.

To write down, or know the Value of a Decimal of Money by Inſpection.

EXAMPLE I.

Value of .1234 *l.*
Is = 2 *s.* $5\frac{1}{2}$ *d.*

EXAM-

EXAMPLE II.

Value of .456 *l.*
Is = 9 *s.* $1\frac{1}{2}$ *d. fere.*

EXAMPLE III.

Value of .6789 *l.*
Is = 13 *s.* 7 *d. propè.*

I have about Thirty-three Years ago publiſhed this Rule in *The Merchant's Magazine*, whoſe Vending hath been a ſufficient Indication of its Uſefulneſs.

In *Example* I. Double the Prime's Place is 2 *s.* and the 23 in the ſecond and third Places, are 23 Farthings, leſs 1, becauſe above 13 is 22, or $5\frac{1}{2}$ *d.*

In *Example* II. Double the 4 in Prime's Place is 8; and becauſe the Second's Place amounts to 5, add 1 is = 9 *s.* and the 6 is Farthings: So 9 *s.* $1\frac{1}{2}$ *d.* is the Anſwer.

In *Example* III. Double the Prime's Place is 12; to which add 1, becauſe the Second's Place is not leſs than 5, makes 13 *s.* Then the 2 above 5 in the Second's Place, and 8 in the Third's Place, I call 28 Farthings; which I ſhould make leſs by 1, (as under the firſt *Example*) but do not, becauſe the fourth Place from the Point is above 6. So 28 Farthings is 7 *d.*; and 13 *s.* and 7 *d.* is the Anſwer.

Note, I was the firſt that gave the Reaſon of this Rule in my Book above.

PROP. XIX.

To find the Value of the Decimal of a Pound Troy (moſtly) by Inſpection.

EXAMPLE I.

.8765

℥ 10.5180

Or, ℥ 10. *dwt.* 10. *gr.* 9.

EXAMPLE II.

.7654

℥ 9.1848

Or, ℥ 9. *dwt.* 3. *gr.* 17.

EXAMPLE III.

.5432

℥ 6.5184

Or, ℥ 6. *dwt.* 10. *gr.* 9.

The Penny-weights and Grains found entirely by Inſpection; as follows:

The *Anſwers* to the three laſt *Examples* are produced thus:

Firſt, Multiply the given Number by 2, and add the Digit next the Right Hand to the Product, &c. and when you come to the Digit next the Left Hand, and have multiplied that, add the Tens carried to that Digit, which in the firſt *Example* is 10.5180 ℥. And ſo of the reſt.

Secondly, For Penny-weights, double the Prime's Place of the Decimals of an Ounce, and if the Second's Place be 5, or more, add 1; (as in the ſecond *Example*.)

Thirdly, For the Grains, take half what the Second's Place is above or under 5, and the Third's Place, for Grains. So in the ſaid ſecond *Example*, 8 is 3 above 5; which 30 added to the Third's Place, 4, is 34; half of which is 17 Grains: And ſo of the reſt. Which is all new and eaſy.

See alſo *Prop.* XXII. for the Decimal of a Foot by Inſpection.

PROP. XX.

When the Value of any Integer is 2, the Value of any Number is known, by cutting off Unit's Place with a Point. So those towards the Left Hand are Pounds, and thoſe towards the Right are ſo many 2 Shillings.

EXAMPLE I.

1234 at 2 *s.* each

Are, 123 *l.* 8 *s.*

EXAMPLE II.

56789 at 2 *s.*

Are 5678 *l.* 18 *s.*

EXAMPLE III.

98765 at 2 *s.*

Are, 9876 *l.* 10 *s.*

PROP. XXI.

If the Value of an Integer is any even Number of Shillings, the Value of the whole is found, without putting down a Figure beſides the *Anſwer.*

EXAMPLE I.

1234 at 14*s.*
Is *l.* 863.8. Anſwer.

EXAMPLE II.

4567 at 16*s.*
Is *l.* 3653.6. Anſwer.

EXAMPLE III.

6789 at 18*s.*
Is *l.* 6110.1. Anſwer.

This is done by multiplying the Number of Integers by half the Price of 1, and cutting Unit's Place with a Point from the Product. So in the firſt *Example*, 7 times 1234 is 863.8, *&c.* and the Digits cut off are Decimals of a Pound: In the firſt *Example*, 16*s.* in the ſecond, 12 *s.* *&c.* by *Prop.* XVIII. for valuing a Decimal by Inſpection. *Vid. Prop.* XXIII.

PROP. XXII.

The Value of the Decimal of a Foot in Inches and Quarters is thus found by Inſpection eaſily.

EXAMPLE I.

.26 Foot.

Value = 3 Inches, 0 Quarters.

EXAMPLE II.

.45 Foot.

Value = 5 Inches, 2 Quarters.

EXAMPLE III.

.89 Foot.

Value = 10 Inches, 2 Quarters.

The Prime's Place is ſo many Inches and ſo many Quarters.

The Second's Place is ſo many Half-Quarters. But if it be 3, or upward to 6, deduct 1; 6, or upward to 9, deduct 2; 9, 3. Never done before by any other. Two of the following Ways are alſo New.

PROP. XXIII.

When the Value of an Integer is any odd Number of Shillings, the Price of any Number of thoſe Integers may be found by theſe three ſhort Ways.

The firſt Way.

5432 at 13 *s.* each.

Add { *l.* 3259.2
      271 — 12 *s.*

Sum *l.* 3530 — 16 *s.* Anſwer.

The ſecond Way.

5432 at 13 *s.* each.

7061.6

l. 3530 — 16 *s.* Anſwer.

The

The third Way.

5432 at 13 s. each

.65

l. 3530 — 16 *s.* Anſwer.

In the firſt Way I work for 12 *s.* as is done under *Prop.* XXI. and to the Product add half the 5432, except Unit's Place.

In the ſecond Way I multiply the 5432 by 3, and add the Figure next the Right Hand as I proceed, *&c.* As under *Prop.* XIX. *Rule* the Firſt.

In the third Way I multiply the given 5432 by 65 = the Decimal of 13 *s.* which is eaſily done without making a Digit beſides the Anſwer: For I ſay, 5 times 2 is 10, 0 and carry 1; 5 times 3 is 15, and 1 is 16, and 6 times 2, or 12, is 28, put 8 down, and carry 2, *&c.* So that Product is *l.* 3530.80, or *l.* 3530, and the .8, by the *Rule* under *Prop.* XXI. is 16 *s.*

This Way of multiplying by two Figures is very eaſy when much uſed. I ſeldom make two Lines for two Figures in the Multiplier, as appears by the next *Propoſition.*

PROP. XXIV.

Out of twenty Things, how many different Parcels (each 10) may be had?

To anſwer this, the Number of Parcels from 1 upward muſt be multiplied together continually for a Diviſor; and ſo many of the 20 as there are Parcels muſt be multiplied one in another, beginning at 20, *&c.* downward for a Dividend. So the Quot. is the Anſwer.

EXAMPLE.

```
       1                          20
       2                          19
     ---                        ----
       2                         380
       3                          18
     ---                        ----
       6                        6840
       4                          17
     ---                      ------
      24                      116280
       5                          16
     120                     -------
       6                     1860480
    ----                          15
     720                    --------
       7                    27907200
    5040                          14
       8                   ---------
   -----                   390700800
   40320                          13
     9& 10                ----------
 -------                  5079110400
 3628800= Divisor.                12
                         -----------
                         60949324800
                                  11
                        ------------
                        )670442572800(184756=
                          307562      [Quot. or Anſ.
                           172585
                            274337
                             203212
                              217728
                                  0
```

If it be thought that the laſt *Propoſition* is the ſame with the XVIth, the Miſtake will eaſily be rectify'd, if it be conſider'd, That both the *Dividend* and the *Diviſor* laſt above, are much different; the former here being 11 times as much as it would have been by the *Rule* under the XVIth *Propoſition*, the latter 10 times ſo much; and this Quot. inſtead of 184756, would have been but 167960. But another Thing very obſervable, is, That there ſhould in neither under this nor *Prop.* XVI. be any Remainders in dividing ſuch large Sums, nor in any other of like Sort with either. And it may ſeem the moſt ſtrange of all, that 184756 different Parcels of 10 ſhould be contained in 20 Things of any kind of Individuals.

PROP. XXV.

The Powers of the nine Digits, with Observations thereon.

	Squ.	*Cube*	*Biqu.*	*Surſolid.*	*Squ. Cube.*	*2d Surſolid.*	*Squ. Biquad.*	*Cubed Cube.*
1	2.	3.	4.	5.	6.	7.	8.	*Exp.* 9.
1	1	1	1	1	1	1	1	1
2	4	8	16	32	64	128	256	512
3	9	27	81	243	729	2187	6561	19683
4	16	64	256	1024	4096	16384	65536	262144
5	25	125	625	3225	15625	78125	390625	1953125
6	36	216	1296	7776	46656	279936	1679616	10077696
7	49	343	2401	16807	117649	823543	5764801	40353607
8	64	512	4096	32768	262144	2097152	16777216	134217728
9	81	729	6561	59049	531441	4782969	43046721	387420489

OBSER-

OBSERVATIONS.

I. That the Unit's Place of all the Powers of 5 and of 6, are 5 and 6 reſpectively, and are therefore called ſpherical or circular Numbers.

II. That the Unit's Places of the Powers of 4, are 6 and 4 alternately.

III. And thoſe of 9, are 1 and 9 alternately.

IV. Unit's Place of the Square and ſquared Cube

V. Unit's Place of the Cube and Surſolid

VI. Unit's Place of the Biquadrate and ſquare Biquadrate

VII. Unit's Place of the Surſolid and cubed Cube, *viz.* The Places of the Powers 2d and 6th, 3d and 7th, 4th and 8th, 5th and 9th

Are juſt the ſame from Top to Bottom; and the 2 laſt are the 9 Digits each; which is the XIth Obſervation.

VIII. That the Number of Places in the Powers of 8 and 9, are equal to the Roots 8 and 9.

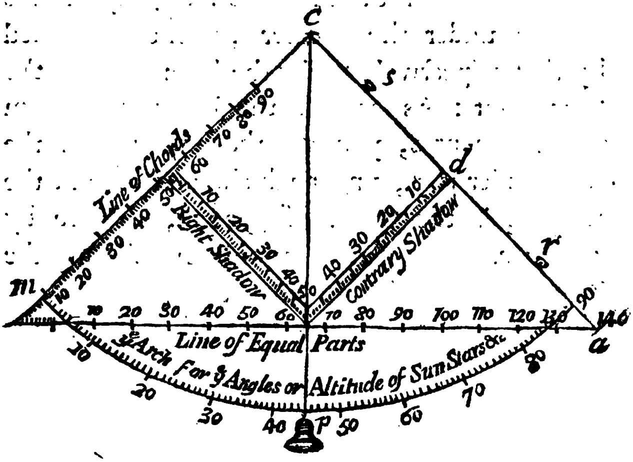
IX. The Exponents of the Square being 2, of the Cube 3, the Biquadrate 4, the Surſolid 5, Cubed Cube 6, *&c.* I ſay the Sum of the Exponents of any two Powers is equal to the Exponent of the Rectangle of thoſe Powers: So where the Root is 4, and the Exponents 2 and 6; I ſay, the Sum of the Exponents 2 and 6 is 8, equal to the Exponent of the Rectangle of the Powers 4096 by 16 = 65536: As by the *Table.* And Double the Exponent is = that of the Square of the Powers.

X. and Laſtly, If from any Exponent you take another, the Power under the remaining Exponent ſhall be the Quot. of any of the Powers under the greater Exponent, divided by that reſpectively under the leſſer, having the ſame Root: As againſt the Root 5, if from the Exponent 8, you take the Exponent 3, the Remainder is 5; under which, and againſt the Root 5, is the Quot. of 390625, divided by 125, *i. e.* 3125, found by only ſubtracting the Exponent. And ſo of any others.

SECT. VIII.

INSTRUCTIONS *how to take* Heights, Depths, *and* Diſtances, *ſeveral Ways*, great *or* ſmall.

The QUADRATIC INSTRUMENT.



1. To

I. *To take* ALTITUDES.

1. *The Uſe of the Square q, a, d, c, q, and the Line and Plummet c, p.*

PROPOSITION I.

To take the Altitude of a Tower, Steeple, Houſe, Tree, &c.

LOOK at the Top of the Object through the Sight *r*, *s*, (with *r* next your Eye) and go forward or backward, till, at the ſame time that you ſee the Top of the Object, the Plumb-Line falls at 50 Parts in the Square: Then meaſure from your Foot to the Bottom of the Object where it touches the Surface of the Earth, and that Diſtance, adding the Diſtance of your Eye from the Ground, is the Altitude of the Object required.

So if I find from my Foot (for *Example*) to the Bottom of the Object, 91 Foot, more 5 is 96 Foot, the Height required.

2. *The Uſe of the Side Right Shadow q, a.*

PROP. II.

To take the Height of any Object from any Place to which you can meaſure on even Ground from the Bottom of ſuch Object.

The foregoing Method is for ſuch as underſtand not the Rule of Proportion: This is for ſuch as do.

The Uſe of the Foreſide, or Right Shadow, is for ſuch Diſtances of the Place where you obſerve to the Bottom of the Object as exceeds the Height of that Object.

EXAMPLE.

I will take the Altitude of the foregoing Object from a Station which I will ſuppoſe 120 Foot from the Bottom (becauſe I cannot come nearer it, by reaſon of ſome Impediment or Water or Moraſs, &c. but can ſend one round with a Clue of Packthread, keeping one End in my Hand to meaſure the Diſtance;) at which Diſtance looking through the Sights at the Top of the Object, I find the Plumb-Line cutteth

40 Parts: Then I ſay, by the Rule of Proportion,

As 50, the whole of the Fore-ſide, or Right Shadow:

Is to 120, the whole Diſtance ::

So is 40 Parts cut by the Line:

To 96, the Altitude of the Object required (as before.) Thus,

```
        50  :  120  ::  40
                40
              ------
          50)480.0(96 = the Altitude, as
               ---                [above.
               30
               ---
                0
```

3. *The Uſe of the contrary Shadow a, d.*

PROP. III.

To take the Height of any Object from which you cannot go ſo far backward as to make the Thread fall at 50 Parts.

EXAMPLE.

I will ſuppoſe I were to take the Altitude of the foregoing Object, but cannot go farther from the Bottom of the Object than 72 Foot (by reaſon of ſome Impediment behind me;) where looking through the Sight at the Top of the Tower, &c. the Thread cuts 37.5 in contrary (or back) Shadow. Then I ſay,

As the Parts cut by the Thread = 37.5 :

Is to the Diſtance that I am from the Bottom of the Tower (more Height of my Eye) 72 : :

So is 50, the whole of contrary Shadow :

To the Altitude as before = 96. Thus,

37.5 : 72 :: 50

50

37.5)3600.0(96 = the Altitude as [before.

2250

0.0

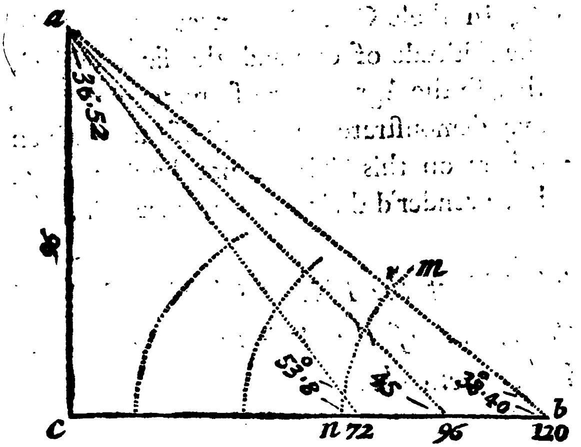
Note, In theſe Caſes it is neceſſary to take the Altitude of one and the ſame Object, that ſo the Agreement of the ſeveral Ways may demonſtrate the Truth of each; which others on this Subject not having done, have render'd their Anſwers uncertain.

4. *The Uſe of the Line of Chords, of Equal Parts, and of the Arch in the* Quadratic Inſtrument *above.*

PROP. IV.

The ſecond Propoſition above performed by theſe Lines geometrically, according to the following Scheme, which is a Demonſtration of the Truth of the three firſt Propoſitions.

In Prop.	*The Parts cut in the Square by the Thr.*		*Which is at Degrees in the Arch:*		*And is the Quantity of the Angle.*
1	— 45	—	45	—	*a*, 96, *c*
2	— 40	—	38.40	—	*a*, *b*, *c*
3	— 37½ in con. Sh.		53.8	—	*a*, 72, *c*



So without the Square, only by the three Lines above, to take the Altitude of *c a*; I ſtand at *b*, becauſe I cannot well come nearer, and looking at *a* through the Sights, I find the Thread cuts 38° 40′; and meaſuring the Diſtance *b c*, I find it 120 Foot.

5. *Now*

5. *Now to lay this down upon Paper,*

I draw a Line, *c b*, at Pleaſure; then taking 120 from the Line of Equal Parts on the Inſtrument, it extends from *c* to *b*; Thirdly, I erect the Perpendicular *c a*; Fourthly, With 60 Degrees of the Line of Chords, ſetting one Foot of the Compaſſes in *b*, I deſcribe the Arch *n*, *m*; Fifthly, Becauſe the Angle at *b* (or *a b c*) is 38.40, I therefore take that from the ſame Line of Chords, and ſet it from *n* to *r*; Sixthly, I lay a Ruler from *b* to *r*, and draw a Line from *b*, till it interſect the Perpendicular *c a*, which it doth in *a*; therefore, Seventhly, I take the Diſtance *c a*, and applying it to the ſaid Line of Equal Parts, I find it 96, = the true Altitude required. And alſo in like manner may you take the Height at the other *z*, &c. Stations.

And *note* farther, That by this Way you have alſo the Hypothenuſe *a b*, by taking it between your Compaſſes, and applying it to the ſame Scale of equal Parts; which is done eaſier and ſpeedier than by the 47, 1 *Euclid*, of taking the ſquare Root of the Sum of the Squares of the Baſe and Perpendicular *c b* and *c a*.

6. *A third Way to find the Altitude* ca, Arithmetically.

Having with the foregoing Inſtrument taken the Angle at the Station b, and the Diſtance bc; ſay,

As Radius	10.
To the Diſtance $bc = 120$, its Log.	2.079181
So is the Tangent of the Angle at $b = 38^{\circ}\ 40'$	9.903199
To the Log. of $ca = 96$	1.982380

And ſo of any other Altitude, and the other Stations for this.

PROP. V.

To take greater Altitudes, as of the Stars, Sun, or Moon, by the Quadratic Inſtrument.

Look through the Sights, with r next your Eye, and when you ſee the Star, obſerve how many Degrees are cut in the Arch by the Thread from m towards 90; and ſo many are the Altitude above the Horizon.

2. Or, for the Sun: You may hold up your Quadrant with *s* next the Sun, and when the Point of the Sun, ſhining through the Hole at *s*, falls upon the Hole at *r*, the Degrees then cut by the Thread in the Arch, is the Sun's Altitude above the Horizon.

3. For the Meridian Altitude: Take the Altitude of the Sun, as before, at 12 a-Clock, by ſome good Dial that hath Minutes, and making Allowance for the Time in the Table of the Equation of natural Days, the Degrees cut by the Thread ſhew the Meridian Altitude of the Sun that Day.

II. *To take* DEPTHS *ſeveral Ways.*

PROP. I.

How to take the Depth of any Well, or of the Eye of any Coal or Lead-Mine, &c.

A TABLE *ſhewing the Feet that an heavy Body falls in any Number of Seconds, not exceeding* 12, *and to take Depths thereby; and alſo without the* Table, *by the* 4 *of the* Iſt, *and* 3 *of the* IId *Prop.*

Seconds an heavy Body falls.	Feet it falls in each Second.	Sums of the Feet that it falls.
1	16	16
2	48	64
3	80	144
4	112	256
5	144	400
6	176	576
7	208	784
8	240	1024
9	272	1296
10	304	1600
11	336	1936
12	368	2304

This *Table* is made ſeveral Ways:

1. For if you multiply the firſt of the Middle Column by 3, it gives the 2d Number; by 5 the 3d, by 7 the 4th, *&c.* Or,

2. If you add 32 to the 1ſt, *&c.* continually, you will have all the Numbers in the ſecond Column.

3. If you add the two firſt Numbers in the middle Column, you have the ſecond Number in the third Column; the three firſt in the ſecond gives the third in the third, *&c.* Or,

4. Without the ſecond or third Columns, the Sum of the Feet that any Body falls in any Number of Seconds may be found by conſidering that the Diſtance is as the Square of the Time. So if you would know how far a heavy Body falls in 5 Seconds, I ſay,

As 1 : 16 :: $5^2=25$: 400.

As in the third Column.

Or in 6 Seconds ſay;

1 : 16 :: $6^2=36$: 576

As in Col. 3, *&c.*

PROP.

PROP. II.

To take a Depth by your Watch and the third Column.

Obſerve how many Beats of the Watch there are between letting the Body fall, and hearing the Sound of it when it comes to the Bottom, which ſuppoſe 12: Now in 12 Beats, reckoning 4 to 1 Second, is 3 Seconds; againſt which, in the third Column, is 144 Foot, the Depth.

For a IId EXAMPLE.

Suppoſe it 24 Beats of the Watch from the Time it is let fall, to the Time you hear the Sound at the Bottom; that divided by 4 is 6 Seconds; right againſt which, in the third Column, is 576 Foot, or 192 Yards, the required Depth.

EXAMPLE III.

Suppoſe the Time of falling is 22 Beats of the Watch, which is 5.5 Seconds; then by the 4th Paragraph above,

As $\overset{''}{1} : \overset{F.}{16} :: \overset{''}{5.5^2} : \overset{Foot.}{484}$, or $161\frac{1}{3}$ Yards, = the Depth, without the Table above.

So much for taking Depths in the Medium of Air. Now for Water.

But *note*, The Body you let fall may be about 5.25 Inches Diameter, and Round.

Note alſo, That 5.5^2 is 5 and an half ſquared or multiplied in it ſelf; and ſo 6^2 is 6 ſquared.

The Depth above being in Air, what follows in this *Propoſition* is in the Medium of Water.

PROP. III.

How to take any Depth at Sea, without a Sounding Line.

In order to which, I ſhall give the following *TABLE.*

Time

Time from Immerſion to Emerſion.	Fathoms deep.
″	
1	.5+
2	1.1−
3	1.6−
4	2.1+
5	2.6+
6	3.2−
7	3·7−
8	4·2+
9	4·8−
10	5·3−
11	5.8+
12	6.3+
13	6.9−
14	7·4−
15	7·9+
16	8.4+
17	9·0−
18	9·5

Time from Immerſion to Emerſion.	*Fathoms deep.*
″ 19	10.0+
20	10.6−
21	11.1−
22	11.6+
23	12.1+
24	12.7−
25	13.2−
26	13.7+
27	14.2+
28	14.8−
29	15.3+
30	15.8+
31	16.4−
32	16.9−
33	17.4+
34	17.9+
35	18.5−
36	19.

Time from Immerſion to Emerſion.	*Fathoms deep.*
″	
37	19.3+
38	20.1−
39	20.6−
40	21.1+
41	21.6+
42	22.2−
43	22.7−
44	23.2+
45	23.8−
46	24.3−
47	24.8+
48	25.3+
49	25.9−
50	26.4−
51	26.9+
52	27.4+
53	28.0−
54	28.5−

Time from Immerſion to Emerſion.		*Fathoms deep.*
″		
55	—	29.0 +
56	—	29.6 —
57	—	30.1 —
58	—	30.6 +
59	—	31.1 +
60	—	31.7 —

It hath been tried in ſhallow Water, that if you take a varniſh'd Ball of light Wood, and on that fix a Hook a very little hooked, and to that hang a Weight that will eaſily ſink it; when the Weight comes plump to the Bottom, the Ball will be diſengaged, and come up again; and from the Time the Ball is all covered with the Water, to the Time it appears again, *i. e.* from its Immerſion to its Emerſion, being found in the *Table* (taken by the Beats of a Watch, or rather by a Pendulum, which vibrateth Seconds, to ſave the Trouble of dividing the Beats by 4) right againſt that Time you have the Depth; as hath been found by Experiments. Which *Table* is grounded on this Proportion, that the Ball will be under Water 6 Seconds, when the Depth is 3 Fathom and 1 Sixth, or 3.166666; or, as 36 to 19.

Or if your Depth exceed what is in the *Table*; as, admit the Ball is immers'd 285 Seconds: If you multiply .52777, which are the Fathoms anſwering to 1 Second (according to the Proportion aboveſaid) by the 285, the Product will give the Depth = 150.4 Fathom.

Note, That + in the foregoing *Table* ſignifyeth *more*, but not ſo much more as .05; and that — is *leſs*, but not ſo much leſs as .05: Or, the Depth to the Time is near 1 Yard in 1 Second, being but about 3 Yards over in 60 Seconds; as by the *Table*.

PROP. IV.

Being at the Top of a Tower, &c. *how to take the Depth or Length down to the Bottom or Surface of the Earth, by Help of the foregoing* Quadratic Inſtrument.

I will inſtance in the Diſtance under *Prop.* II. for taking Altitudes. Being at the Top of the Tower *a c*, (ſee the Triangle *a b c*) I order ſome one to ſet up a Mark at *b*; then I look at that thro' the Sights, with that Sight next my Eye which is next *c* the Center, and I find the Thread cuts 51° 20′, which is the Angle *c a b*, or at *a*; then I ſubtract 51° 20′ from 90, and the Remainder is 38.40. the Angle *a b c*. Then I ſay,

As the Sine of 51.20 ——	9.892536
Is to the Log. of the diſt. meaſur'd *c b* = 120 ——	2.079181
So is the Sine of the Angle at *b*, 38.40 ——	9.795733
To the Log. of the Depth *a c* = 96 -	1.982278

Or this may be done Geometrically in all Reſpects, as under the ſaid IVth *Propoſition* for taking Altitudes; after you have acquired the Angle *a b c*, or at *b*, by taking the Complement of 51.20 to 90.

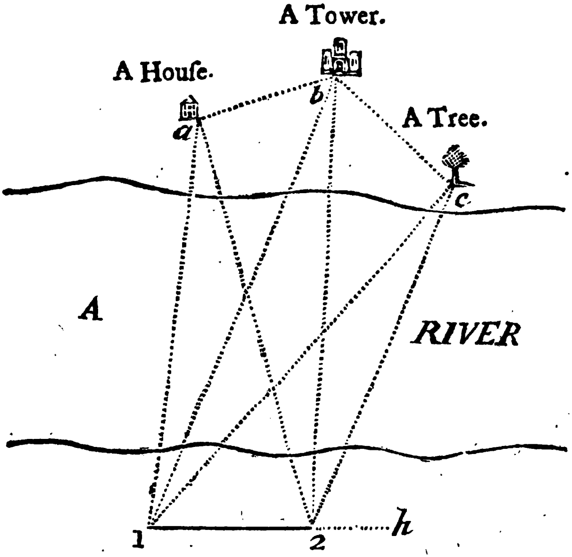
III. *To* take DISTANCES *ſeveral Ways.*

PROP. I.

To take leſſer Diſtances by the plain Table, *and ſuppoſing the Places are inacceſſible from the Places where you make your Obſervations.*

As for EXAMPLE.

Admit it were required to take the Diſtances following from 1 to *a*, to *b*, to *c*, *&c.* over a River: I place my Inſtrument at 1; and applying the Edge of the Index to that End of the



40 Pole, or 220 Yards, or 10 Gunter's Chains.

the ſtationary Line, I turn it till I can ſee the Mark at *a*, and then draw a Line by the Side of the Index directly towards *a*, as 1 *a*; then keeping the Edge to the ſame Point, I turn the Index till through the Sights I can ſee the Bottom of the Tower at *b*, and then I draw the Line on the Head of the Table, as 1 *b*, and then I turn the Index till I ſee the Tree at *c*, and draw the Line 1 *c*. All the three Lines thus drawn at Pleaſure, I put a Mark at Station 1, and meaſure from thence to a ſecond Station at 2, which ſuppoſe I find 40 Pole, this I take from the Scale of equal Parts, and ſet on a Line drawn at pleaſure, as 1 *b* from 1 to 2.

Then I remove my Inſtrument from 1 to 2, the ſecond Station, and laying the Edge of the Index to the Line 2, 1, I turn the Head of the Table, till, through the Sights, I ſee the former Station at 1, and then I turn the Index to *a*, *b*, and *c*, as before; and drawing Lines 2 *a*, 2 *b*, and 2 *c*, they will cut the former Lines in *a*, *b*, &*c*. Then any of the Lines above being applied to the ſame Scale that the ſtationary Diſtance 1, 2 was meaſur'd by, gives its Length. So that by the two Stations forming the Scheme above you have taken eight ſeveral Diſtances; *i. e.*

The pointed Line		Statute Pole.		Yards.
1, *a* is	=	94	or ——	517
1, *b* —	=	113	——	$621\frac{1}{2}$
1, *c* —	=	114	——	627
2, *a* —	=	95	——	$522\frac{1}{2}$
2, *b* —	=	102	——	561
2, *c* —	=	91	——	$500\frac{1}{2}$
a, *b* —	=	33	——	$181\frac{1}{2}$
b, *c* —	=	37	——	$203\frac{1}{2}$

And the River between the two Stations and the Objects is almoſt a Quarter of a Mile broad.

Note, A Statute Pole is 5 Yards and an half: And I have taken theſe Diſtances in Poles meaſured by the Line of Equal Parts in the foregoing *Quadratic Inſtrument.*

PROP. II.

To take a Diſtance from a known Height by Help of the ſaid Quadratic Inſtrument.

Under *Prop.* IV. for taking Altitudes, admit I am at the Top of the Tower *c a*, and would find the Diſtance *c* 72, or any other, (tho' 10 times that) I take the *Quadratic Inſtrument*, and looking from *a* through the Sights, with that next the Center neareſt my Eye, I find the Angle at *a* (or *c a* 72) 36° 52′, whoſe Complement is 53.8: Therefore to find the Diſtance (*c* 72) I ſay,

As the Sine of 53° 8′ —— 9.903108

Is to the Log. of *c a* = 96 —— 1.982271

So is the Sine of 36.52 —— 9.778119

To the Log. of 72, &c. = the Diſtance required —— } 1.857282

Or Geometrically: Draw two Lines at Pleaſure, but perpendicular to each other (as *c b* and *c a* under the ſaid *Prop.* IV. for Altitudes;) then from the Scale of equal Parts on the *Quadratic Inſtrument*, ſet off the known Height *c a*, = 96; then at *a* lay down the Angle, =36.52, and drawing the Line from *a*, it will cut *c b* in 72; which is the Diſtance required, = *c* 72.

PROP. III.

To take the Diſtance by Help of your Watch; as, admit it were required to know the Diſtance to the Place where a Cannon is diſcharg'd, let it be never ſo far off, provided you ſee the Flaſh of Fire, and hear the Sound.

A very ingenious Perſon tells us, that Sound proceeds 968 Foot in a Second of Time; another ſays, more than 1100 Foot: But we will put it at 1000 (being a round Number between them.) Now upon ſeeing the Flaſh of a Gun's Powder, I tell the Beats of my Watch, till I hear the Sound or Report of the Diſcharge, which ſuppoſe 20 Beats or Impulſes; I divide that by 4, gives 5 Seconds, which is 5000 Foot, or 1666 $\frac{2}{3}$ Yards, the Anſwer; which is 1760, or 1 Mile, wanting only 93 $\frac{1}{3}$ Yards.

EXAM-

EXAMPLE II.

Suppoſe the Caſe of Thunder: I take the Beats between the Lightning and the Thunder, which ſuppoſe 52 Beats of my Watch, or 13 Seconds, which is 13000 Foot, or near 2 Miles and an half.

FINIS.

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